POWER

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Do Your Own Thinking!

FOR fifteen years old Tom Smith had been running the pumping engine at Brown's Falls. For fifteen years old Tom climbed up twelve feet on a ladder every day to squirt oil in a little hole in a valve-motion rockshaft.

One day he slipped and nearly fell. The Super saw it and investigated. "What were you doing up there?" the Super asked.

"Shot a little oil into that hole up there."

"What hole?" returned the Super.

Tom showed him.

"Why man!" exclaimed the Super, "that's no oil hole; that's only a lathe center —what they turned the shaft on when they made it!"

So it was. We all know how old Tom felt when he found out that the hole he had faithfully oiled so long was only a blind alley. That's the difference between men—some use their brains and some don't. That's the difference between the Tom Smith and the Tom Edison type of man. The fellow that does his own thinking gets paid for it.

Did it ever occur to you that the man who needs much supervision pays for it? He certainly does. He pays the difference between what he might be getting and what he is getting paid for his work. The more you know and the more thinking you can do for your work, the more you are eventually going to be paid. Then, too, the more you know and the more thinking you can do for the boss, the sooner will he put you where you can supervise the work of others and be paid accordingly. DO YOUR OWN THINKING!

Contributed by John S. Carpenter.

Composition and Use of Babbitt Metals

By B. H. JARVIS

Desirable qualities of babbitt metals, changes in manufacture that have taken place recently and the probable future of these metals as applied to the industries.

WHEN years ago the first anti-friction metal was produced and patented as "babbitt metal" a great impetus was given to the mechanical industries by the fact that such a metal permitted gains in speed, weight, complexity and efficiency, all with greater production possibilities. Babbitt metal was the forerunner of a seemingly endless procession of alloys, many of which possessed merit and have thereby remained in use, while many others, after attracting some notice, were disqualified and dropped into disuse.

Bearing metals of the babbitt or white-metal class with few exceptions have been of tin or lead base, hardened by the addition of antimony and also copper, nickel, zinc or some other hard metal. While many refiners and founders have, through skill or fortune, produced alloys that have given highly satisfactory results as antifriction metals, few have realized the underlying fundamental reasons for the success of their particular products of manufacture. Before expressing opinions as to merit, it is necessary to know how to judge. Following are listed the important qualifications of a babbitt metal:

1. Must have a strength in compression considerably in excess of the heaviest load the bearing is to support at the working temperature.

2. Must possess sufficient plasticity, without the quality of brittleness, to adjust its surface to an irregularly applied load, thus distributing load over the bearing. In bearings subject to severe impact, this property in the metal would necessarily have to be curtailed.

3. Should present to the journal a surface void of hard spots. This in connection with the plasticity of the metal, will allow the journal to form a "true bearing" readily, and as the metal wears this wear will be uniform. A metal not homogeneous in structure and containing abrasive material would not satisfy this qualification.

4. Should be of low friction. The word "antifriction" is common in usage but conveys various meanings. While in properly designed and finished bearings a film of oil should separate the journal and bearing, it is a certainty that under extreme conditions of load or in case of insufficient lubrication metallic friction does occur with subsequent heating and loss of power through friction, and accompanied by danger of the shaft being scored or of the loss of the bearing. Considering the fact that when examined under the microscope the surface of a highly polished shaft is extremely rough, it is evident that truly antifriction metal would be necessarily of such material as to offer little resistance to the movement of the rough shaft, for friction is the direct measure and result of this resistance. This leads to the conviction that the easier the babbitt metal is cut, the more antifriction qualities it would possess, and consistent with the qualification, listed previously, the more desirable the metal would be.

5. Must be tight to the shell in which it is poured. Either it must possess little or no shrinkage in passing from the liquid to the solid state and in later cooling, or, owing to peculiarities of the metal that allow it to be peened, it can be forced tightly against the shell. The common method for small bearings has been to form an excellent bond between the bronze back and the babbitt metal by first tinning the shell. Attention should here be called to the almost universal use of antimony in alloying babbitt metals, due in part to the peculiarity of this metal to expand instead of shrink on cooling, so that mixed in proper proportion with tin or lead, an alloy possessing little or no shrinkage could be produced. Oil is a poor conductor of heat, and should even a thin layer be able to get between the babbitt metal and shell of a high-speed bearing, the conduction of heat away from the babbitt that is developed by friction would be insufficient and the accumulation of heat would mean a hot bearing. One reason for

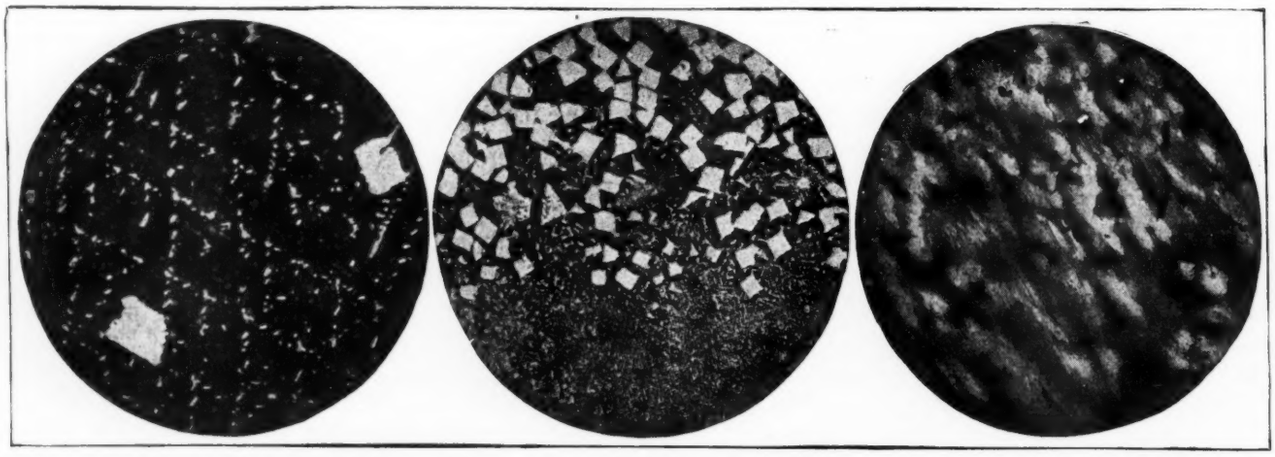


FIG. 1. BABBITT METAL CONTAINING TIN, ANTIMONY AND COPPER

FIG. 2. BEARING METAL CONTAINING LEAD, ANTIMONY AND TIN

FIG. 3. ALLOY CONTAINING TIN, COPPER AND SPELTER

babbitt metals cracking in service, provided they are not of the brittle type, is that insufficient care had been taken to make certain that the babbitt was tight to the shell.

6. For the work at hand the metal must be easily melted, poured and machined. To meet this requirement, only a skillfully alloyed metal can be expected to give the desired results, for, as metals possess various densities, unless properly alloyed, upon being melted the heavier metals present would sink to the bottom. Especially in bearings where the lining of the shell is quite thin, this qualification is exceedingly important.

7. It must possess good wearing qualities. While there are ways of relatively comparing the wearing qualities of babbitt metals, as will be touched on later, the only certain way to determine the service value of a metal for a particular work is to make a service trial.

8. It should not cause excessive wear of the shaft. Lignum-vitæ and other wood preparation bearings would long ago have received more attention had it not been for their excessive wear on the shaft.

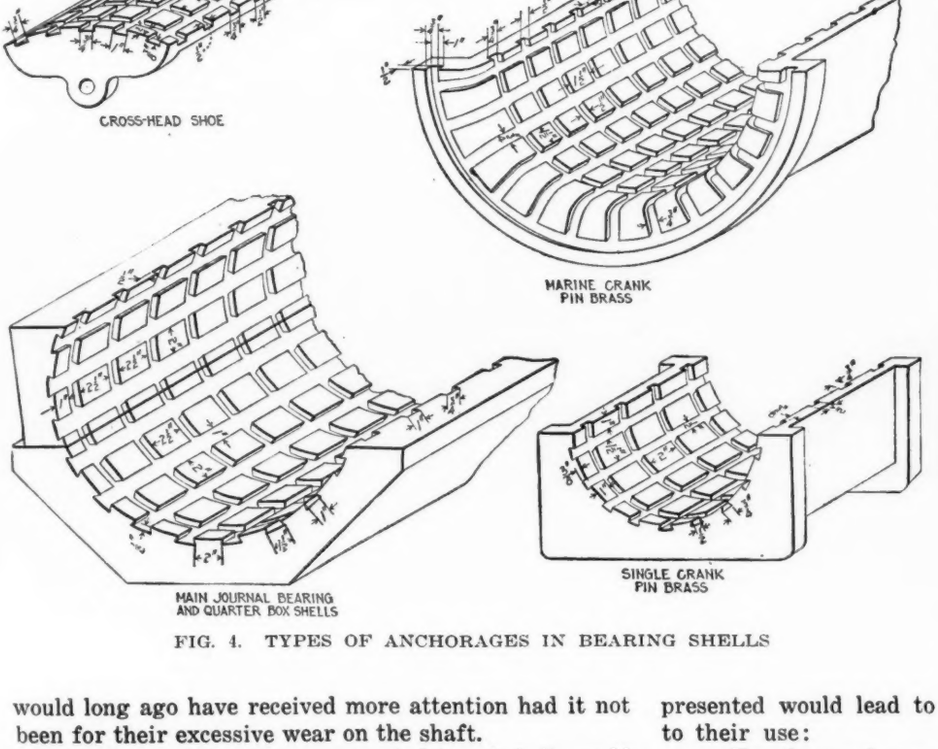


FIG. 4. TYPES OF ANCHORAGES IN BEARING SHELLS

With the qualifications enumerated in mind, it would be of advantage to consider some of the most common types of babbitt. Experience has proved that tin-base, antimony-hardened babbitts have greater wearing qualities than the lead-base, antimony-hardened metals.

Tin, possessing an initial resistance to pressure of about 3,000 lb. per sq.in., needs only a little antimony to counteract its shrinkage and the aid of a little copper to produce an alloy possessing an initial strength in compression of 8,000 lb. per sq.in., of admirable toughness, low in friction, easily worked and of high endurance.

Lead, a metal of much lower friction than tin, possesses only 600 lb. per sq.in. initial resistance to pressure. Having considerable shrinkage, it requires a large amount of antimony to counteract this shrinkage and even with the proper addition of copper, a strength of 5,500 lb. per sq.in. in compression cannot be obtained without producing an alloy so brittle as to be almost worthless.

To both types of babbitt, and in the many combinations of both in order to gain strength and eliminate shrinkage, there have been added materials both hard and abrasive, curtailing certain desirable qualifications for the necessary increase in other essentials. Antimony, of itself able to score steel because of its hard crystalline structure, has been alloyed with either lead or tin, and while affording advantages as regards shrinkage and increase in strength, introduces into the mixture a high-friction, abrasive material.

To a marked degree the relative wearing qualities of two babbitt alloys, hardened by the addition of the same metals, will be found directly related to the strength of the alloys, as indicated by a compression test or a Brinell test for hardness. Experienced mechanics know that a bearing made by pouring a tin-base babbitt around a crankpin or journal will wear much longer than if the pouring is done around a smaller mandrel and the bearing is bored to size. This is due to the slight hardening effect on the surface of the tin-base metal or coming in contact with a cold surface. To some degree, therefore, the wearing or service value of an alloy can be ascertained by measuring its hardness.

In the accompanying table a list is given of the compositions of the most common alloys on the market today, including two metals comparatively new but possessing high qualifications.

Arsenic makes it difficult to tin or solder babbitt to a bronze shell, so the best grade of copper should be used. Only with pure metals and with proper alloying methods can the desired alloys be produced. Judging the alloys in the table by the qualifications previously presented would lead to the following suggestions as to their use:

a. For the maximum of service under excellent operating conditions and regardless of cost, high-speed work as in turbine, generator and motor bearing, alloy No. 1.

b. For resistance to heavy loads and impacts as in large crankpin bearings, alloys Nos. 2, 17 and 18. When thin liners are employed, as in small crankpins or automobile-motor work, alloy No. 2.

c. For resistance to extreme loads and impacts, such as in the piston-pin bearings of Diesel engines, alloy No. 3. For small engines, alloy No. 16 or bronze.

d. Where cost requires the use of a good but cheaper metal for general use in high-speed bearings such as motors, fans, etc., alloys Nos. 4, 5 and 6.

e. For all classes of service where conditions are not severe as to load or speed, such as the main journal bearings of large engines, alloys Nos. 7, 17 and 18.

f. Low speeds, light loads, as in lineshafting bearings, alloys Nos. 10, 11, 12, 17 and 18.

For poor operating conditions as regards the upkeep and alignment of shafting, and dirty operating conditions with poor lubrication, the following recommendations are made:

g. Slow-speed, heavy-pressure bearings, alloys Nos. 13, 15, 17 and 18.

h. High or low-speed, moderate load, subject to impact, alloys Nos. 15, 17 and 18.

i. For high speeds, well lubricated, light load, alloy No. 14.

Alloys Nos. 17 and 18 in the foregoing list are comparatively new metals on the market. They are the results of attempts made to harden lead without the addition of abrasive material, and in this respect they

COMPOSITIONS OF A. S. T. M. TENTATIVE STANDARD ALLOYS

Alloy Grade No.	Tin, Per Cent	Antimony, Per Cent	Lead, Per Cent	Copper, Per Cent	Iron, Per Cent	Arsenic, Per Cent
1	91	4.5	0.35*	4.5	0.08	0.10
2	89	7.5	0.35*	3.5	0.08	0.10
3	83	8.3	0.35*	8.3	0.08	0.10
4	75	12	10	3	0.08	0.15
5	65	15	18	2	0.08	0.15
6	20	15	63.3	1.5	0.08	0.15
7	10	15	75	0.50*	....	0.20
8	5	15	80	0.50*	....	0.20
9	5	10	85	0.50*	....	0.20
10	2	15	83	0.50*	....	0.20
11	..	15	85	0.50*	....	0.25
12	..	10	90	0.50*	....	0.25

SUPPLEMENTARY LIST OF ALLOYS

Alloy Grade No.	Tin, Per Cent	Antimony, Per Cent	Lead, Per Cent	Copper, Per Cent	Zinc, Per Cent	Other Metals
13	70	15	10.5	4.5	..	.....
14	..	25	75	...	..	.....
15	6	18	74	6.0	..	.....
16	65	..	..	5.0	30	.....
17	1.5	..	97	....	..	Alkali metal
18	..	..	98	....	..	Alkali earth metal

* Maximum.

are successful. Experience has shown that these metals are of great value for classes of service such as b, e, f, g, and h listed in the foregoing, and the reason is evident on considering their properties relative to the qualifications of babbitt metals.

They possess strength in compression equal or greater than the highest grades of genuine babbitt, plasticity without brittleness, they contain no abrasive material and are homogeneous in structure, they have the lowest co-efficient of friction of any anti-friction alloys, they are easily poured and machined, they wear well, especially with good operating conditions, and they cause the minimum wear of any alloys on the journals.

Containing no antimony, they do possess one characteristic that must be carefully taken care of for uniform success, and that is shrinkage. Frequently, these metals have been applied successfully in a manner similar to the babbitts and without consideration of the shrinkage, but this success has been due largely to the plasticity of the metals. To take care of the shrinkage, the following changes in design of shells or of methods of pouring are recommended, which, if followed, will enable these alloys to successfully replace babbitt metals to some degree.

As illustrated in Fig. 4, the shells should have plenty of undercut anchorage of the checkerboard type. The grooves should be undercut and not over ½ in. wide. The shells should be heated before pouring, that they may contract in cooling with the bearing metal.

When possible, all bearings, and most certainly those for high speed, should be peened after pouring, and the peening should be sufficient to force the metal right to the shell. These metals are very plastic immediately after solidifying, and with little effort can at this time be peened back to the shell. Due to the anchorage a perfect bond between the bearing metal and shell will be formed.

Where the metal is poured to size in a half-bearing and cannot be machined, it will be advantageous to peen the edges of the bearing, which will both help to increase the bond and relieve the bearing.

It is of importance that all bearings be properly relieved, or else the lubricant will be scraped off the revolving journal by the sharp edge, and a hot bearing will result.

Do not attempt methods of securing tight bearings such as the use of expanding mandrels or by immersion of the shell in water after pouring.

Do not cut oil grooves in the bearing metal except on the portion of the bearing where there is little or no pressure. This applies to all babbitts and bearing metals, for frequently sources of trouble have been traced back to the oil grooves, which, instead of helping to maintain an oil film, afforded a means of exit for the oil and excessive friction resulted.

Absolute confidence in materials used is a mighty good restraint on an engine builder who is tempted to change from a metal he has used successfully to one of which he knows little. But where the fundamental principles have been applied and experience sustains the application, conservatism should bend to progress.

Where the Ammonia Charge Goes

BY J. E. PORTER

In any ice or refrigerating plant the ammonia charge is the most important item with which the engineer has to deal. It is the one big individual thing that really produces results, and it is probably safe to say that it receives the least attention. This is not true in all plants, but will hold good for the large majority.

The initial charge of ammonia comes to a plant in drums and is chemically pure. The ammonia manufacturers are careful about keeping their ammonia drums clean and free from any foreign substance, so that it is fairly safe to assume that when a charge goes wrong, the trouble develops at the plant. Theoretically, the initial charge of ammonia should last indefinitely, but practically there is continual loss. Let us see what happens to a perfectly good charge after being introduced into a new system.

Starting from the liquid receiver, the liquid ammonia passes through the expansion valve into the evaporating or refrigerating coils, from whence it is drawn into the compressor and forced through the condenser and back to the receiver again, making a complete cycle. If there happens to be a leak in any part of the system, some ammonia will be lost. While the peculiar odor of ammonia makes it easy to detect outside leaks, there are two places where serious leaks can develop and not be detected for some time; namely, the brine tank and the condenser. A small leak in the expansion coils, with the brine absorbing the ammonia, will cause a lot of wastage in the course of a season's run. There is an equal opportunity for loss of the charge in the condenser as the ammonia is absorbed and carried away by the cooling water. Another place around which the ammonia slips away into the atmosphere is the packing. This is due largely to the severe conditions under which the packing is required to function. Relatively, it is burning up one minute and freez-

ing the next. In a great many machines it is difficult to adjust the packing so there is no leakage and still keep the running parts cool. While the oil seals at these points help to keep down leakage, there is, nevertheless, considerable ammonia lost around the packing.

It is impossible to operate a plant and not lose some ammonia. Every engineer should be persistent in his efforts to keep these losses as low as possible per ton of ice manufactured. Based on this unit the average cost of ammonia seems to range from $\frac{3}{8}$ to 20c., 10c. being a fair average and about 6c. a good mark to work for. As intimated previously, the only way ammonia is lost is by leakage. It does not deteriorate. The charge, however, can get into a most deplorable condition if not handled properly, by allowing it to become polluted with brine, oil or air.

When the pressure on the ammonia is reduced to or near atmospheric, brine will be drawn into the system if a leak exists in the evaporating coils. Air is drawn in under the same conditions, where leaks are exposed to the atmosphere. Oil enters the system from the compressor lubrication, and it gets in there regardless of the fact that a perfectly good oil intercepter is placed in the discharge line to prevent it from doing so. The reason for this is that the oil, caught in the heat of compression, is partly vaporized and slips by the intercepter along with the ammonia vapor to the condenser and the receiver. If not removed at this point, it finally winds up in the expansion coils, where it does its share in the way of cutting down capacity.

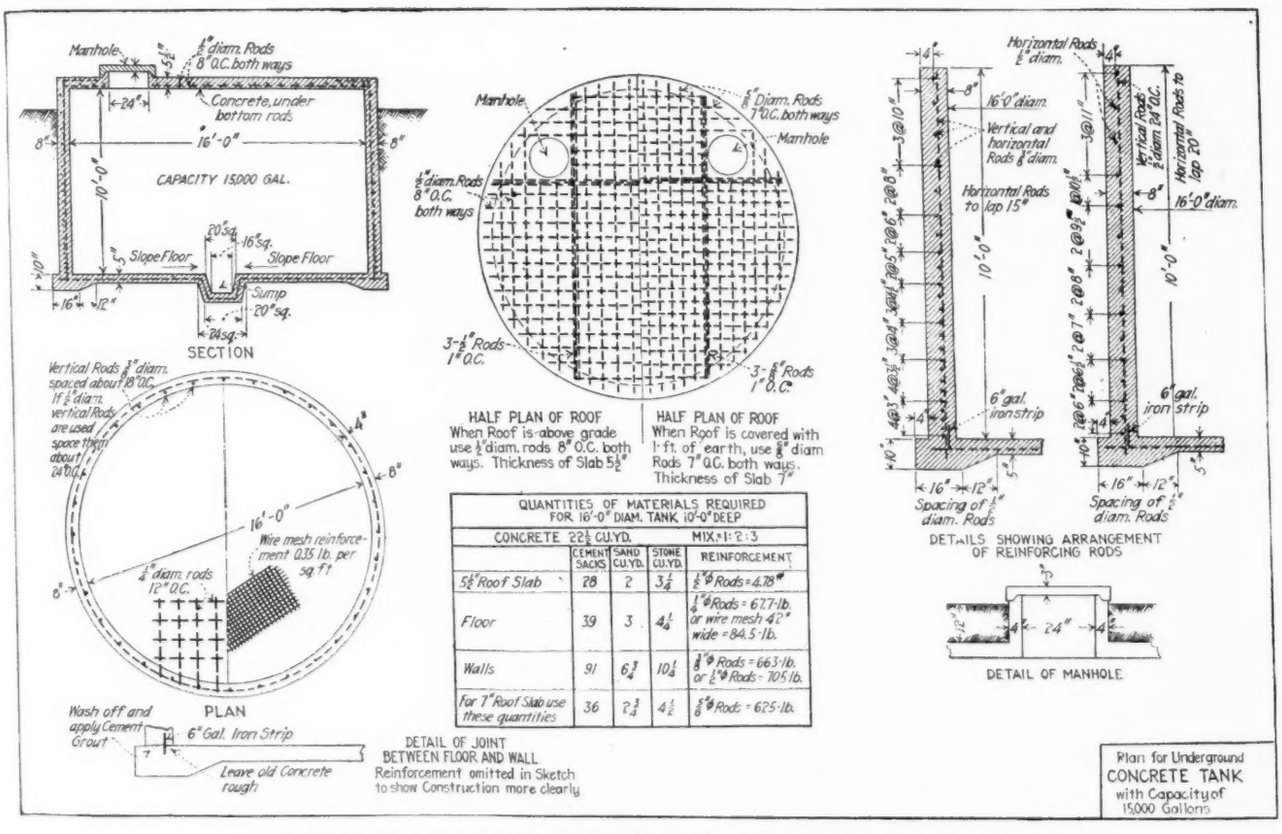
To maintain ammonia sharp and snappy, keep it clean. This can be accomplished by installing a good ammonia regenerator, connecting it to a low point on the receiver and then using it at frequent intervals. If this plan is followed, there will be no trouble from oil in the expansion coils, because to get there it will first have to work its way through the entire high side.

Air in the system will cause excessive head pressure and can be removed only by purging. The purge line should be connected to the highest point on the condenser and led into an open vessel containing water. The compressor is usually stopped during the purging operation and condenser sections allowed to stand for a short while with the water running over them, giving the noncondensable gases a chance to collect at the top. The purge valve is then opened slightly and kept open as long as bubbles appear in the water. The purge valve should be closed when the bubbles disappear, followed by a popping and cracking sound, which indicates that ammonia vapor is entering the water. The machine is then started and run until all is ready to repeat the operation. It usually requires several purgings to rid the system of air.

The ammonia charge never should be entrusted to other than competent hands, for outside of being expensive to lose, it is dangerous if not handled properly. No leak is so small that it should not receive attention, for a small constant leak will eventually get away with as much ammonia as a larger leak which usually requires immediate attention.

Fifteen Thousand-Gallon Concrete Fuel-Oil Tank

The illustration at the bottom of this page is a working drawing for a concrete tank of 15,000 gal. capacity. With slight modifications to meet local requirements and individual tastes, it should be suitable for the storage of fuel oil. The drawing was furnished by the Alpha Portland Cement Company.


Manhole
Concrete, under bottom rods
CAPACITY 15,000 GAL.
Slope Floor
Sump
SECTION
Vertical Rods ⅝" diam. spaced about 8" O.C.
PLAN
Wire mesh reinforcement 0.35 lb. per sq. ft
Wash off and apply Cement Grout
6" Gal. Iron Strip
Leave old Concrete rough
DETAIL OF JOINT BETWEEN FLOOR AND WALL
Reinforcement omitted in Sketch to show Construction more clearly
HALF PLAN OF ROOF
When Roof is above grade use ½" diam. rods 8" O.C. both ways. Thickness of Slab 5½"
HALF PLAN OF ROOF
When Roof is covered with 1'-ft. of earth, use ⅝" diam Rods 7" O.C. both ways. Thickness of Slab 7"
Horizontal Rods ⅝" diam.
Vertical and horizontal Rods ⅝" diam.
Horizontal Rods to lap 15"
Vertical Rods ⅝" diam 24" O.C.
Horizontal Rods to lap 20"
6" gal. iron strip
Spacing of ⅝" diam. Rods
DETAILS SHOWING ARRANGEMENT OF REINFORCING RODS
DETAIL OF MANHOLE

QUANTITIES OF MATERIALS REQUIRED FOR 16'-0" DIAM. TANK 10'-0" DEEP

CONCRETE 22½ CU.YD.			MIX 1:2:3	
	CEMENT SACKS	SAND CU.YD.	STONE CU.YD.	REINFORCEMENT
5½" Roof Slab	28	2	3¼	½" ϕ Rods = 478 lb.
Floor	39	3	4¼	½" ϕ Rods = 677 lb. or wire mesh 42" wide = 845 lb.
Walls	91	6¾	10¼	⅝" ϕ Rods = 663 lb. or ½" ϕ Rods = 705 lb.
For 7" Roof Slab use these quantities	36	2¾	4½	⅝" ϕ Rods = 625 lb.

Plan for Underground CONCRETE TANK with Capacity of 15,000 Gallons

DETAILS OF A 15,000-GAL. UNDERGROUND CONCRETE FUEL-OIL TANK

Explanation and Measurement of Reactive Factor

By VICTOR H. TODD

FOR purposes of calculation, all alternating current not in phase with the voltage, may be said to be made up of two fictitious components, one in phase with the voltage called the "in-phase" or active component and one at right "angles to this component called the "out-of-phase" or reactive component. The terms "energy" component and "wattless" component are often applied, but their use is disapproved by the A.I.E.E. The vector diagram in Fig. 1 shows the current and voltage relation more clearly. Line OE represents an alternating voltage and line OI represents an alternating current lagging behind the voltage by angle ø. Line OI_a represents the in-phase or active component and line OI_r represents the out-of-phase or reactive component. The cosine of the angle ø is the "power factor" and the sine of the angle ø will be the "reactive factor." The product of $OE \times OI_a$ (or $OE \times OI \times \cos ø$ will give the watts in the circuit while the product of $OE \times OI_r$ (or $OE \times OI \times \sin ø$)

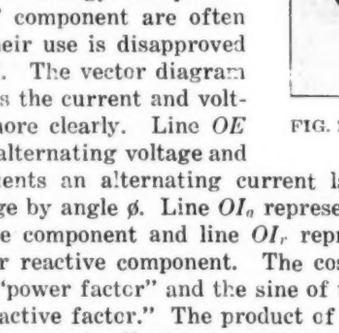


FIG. 1. DIAGRAM REPRESENTING RELATION BETWEEN VOLTS AND AMPERES IN AN A.-C. CIRCUIT

will give the "reactive volt-amperes." When integrated, these two terms become respectively "watt-hours" or "kilowatt-hours" and "reactive volt-ampere-hours" or "reactive kilovolt-ampere-hours."

The simplest means of indicating the reactive factor of a single-phase or polyphase circuit is by a meter similar to Fig. 2. The instrument indicates directly without constants or other calculations, the sine of the angle of phase difference between the current and voltage (reactive factor) and shows if the current is leading or lagging. This is of great importance in reducing the reactive factor of a synchronous converter to zero, that is, adjusting the power factor to unity.

In the three-phase meter, there are three coils wound 60 deg. apart, which produce a rotating magnetic field. Pivoted within this field is a soft iron vane, magnetized with the current in one phase. The vane is without restraining springs, and so assumes a position where its magnetic axis, at the instant of maximum flux, coincides with the position of the rotating magnetic field axis at that instant. In the single-phase instrument, there are two coils, energized through a phase-splitting device.

To obtain the highest accuracy, the current transformers should give between 2 and 5 amperes and the voltage be between 75 and 125 per cent of normal. The instruments are designed only for balanced loads and their indications on an unbalanced polyphase load are not easily interpreted.

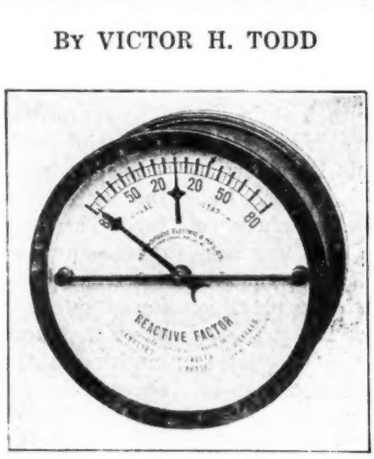


FIG. 2. REACTIVE-FACTOR METER

To check the calibration it is necessary to note the simultaneous readings of volts, amperes and watts. The reactive factor is calculated from the formula:

$$\text{Reactive Factor} = \sqrt{1 - \left(\frac{\text{watts}}{\text{volt-amperes}}\right)^2}$$

On a three-phase circuit, the watts are measured by a polyphase or two single-phase wattmeters, and the volt-amperes equal the sum of the three products—the current in each of the three wires multiplied by the voltage between that wire and an artificial neutral. Or the reactive factor may be calculated by the two polyphase wattmeter method as hereafter described.

Since a wattmeter indicated watts, the product of volts times in-phase current component, it is evident that if we can excite the potential coil of the wattmeter from a voltage which is 90 deg. out-of-phase from the original voltage, then it will indicate the product of volts times out-of-phase current component, or reactive volt-amperes. Referring to Fig. 1, if the wattmeter is connected so its potential coil receives voltage OE, and its current coil receives current OI, then the meter will read watts. But if the potential coil connections are shifted to receive a voltage OE_0 then the meter will read reactive volt-amperes.

On a single-phase circuit, there is no practical way of obtaining this 90-deg. out-of-phase voltage. But on a two-phase circuit, it is only necessary to shift the potential connections to the opposite phases. For instance, in Fig. 3 the diagram shows a polyphase wattmeter connected to read watts, while in Fig. 4 the potential coils are crossed to the opposite phase, thus making the meter read reactive volt-amperes.

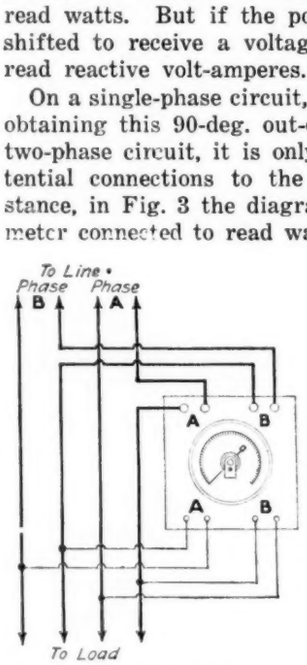


FIG. 3. WATTMETER CONNECTED TO A FOUR-WIRE TWO-PHASE CIRCUIT TO READ WATTS

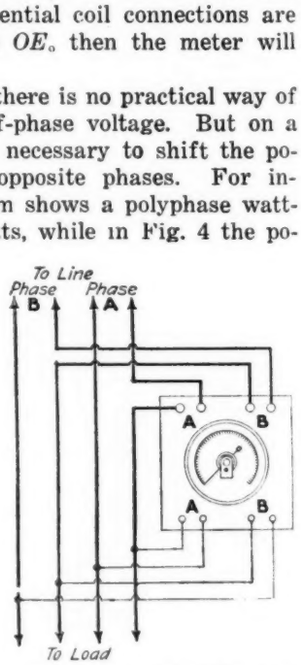


FIG. 4. WATTMETER CONNECTED TO A TWO-PHASE CIRCUIT TO READ REACTIVE VOLT-AMPERES

In a three-phase circuit, the problem is not to supply a voltage 90 deg. away from the current at 100 per cent power factor, but to supply a voltage 90 deg. away from the normal voltage. This distinction is necessary, as it

will be remembered that at 100 per cent power factor, there is a normal phase displacement of 30 deg. between current and voltage. In Fig. 5, *AB*, *BC* and *AC* represent the three-phase voltage vectors. If the current coil of the wattmeter is inserted in the line connected to point *A*, as shown, then the voltage would normally be taken between lines connected to points *AC*. But to obtain a voltage at right angles to this, it is necessary to take it between two points, one midway between *AC*,

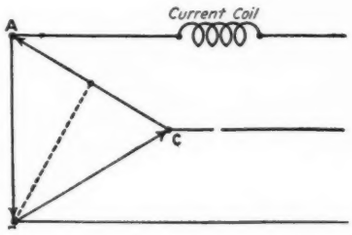


FIG. 5. DIAGRAM REPRESENTING THREE-PHASE VOLTAGES

and the other at *B*. This midpoint may be obtained from the middle-point tap on a transformer or between lamps connected across the phases. The connections for a polyphase wattmeter are shown in Fig. 6, to measure reactive volt-amperes on a three-phase circuit. It will be noticed that the line *BD* in Fig. 5 is not equal in magnitude to the normal voltage *AC*, but is only about 86.6 per cent of it. Consequently, with the connections of Fig. 6, it is necessary to multiply the reading by 1.155 in order to arrive at the true reactive volt-amperes.

When a meter is permanently used to measure reactive volt-amperes, it is usually supplied with special voltage transformers having 57.8, 100 and 115.5 per cent taps, as shown to the right of Fig. 7. The two potential transformers are connected in open delta. For the measurement of watts, the voltage is taken from *O* to E_n, but for measuring the reactive volt-amperes the voltage is taken from E_h to E_m and from E_H to E_M. It will be noted that the voltage from E_h to E_m and from E_H to E_M is equal to and also at right angles to the voltage from *O* to E_n. Oftentimes, a four-pole double-throw knife is used to allow measurement of watts or reactive volt-amperes, by using connections as shown in Fig. 7, throwing the switch to the left for reading watts and to the right for reactive volt-amperes.

The foregoing connections can be used with watt-hour meters, maximum-demand meters and graphic meters. Usually, two meters are used, one to measure the watts and one, reactive volt-amperes. In some cases, the consumer's bill is based on two rates, the operating company charging one rate per kilowatt-hour and another per reactive kilovolt-ampere-hour. The customer is informed that the one meter records waste current which may be largely eliminated by a proper manipulation of his power load. Maximum-demand records of watts and reactive volt-amperes are very valuable, since the power factor, and reactive factor, as well as the time of occurrence may be determined from these readings.

By referring to Fig. 1, it is evident that the tangent of the angle is equal to the ratio of reactive volt-amperes to watts, that is, reactive volt-amperes divided by watts. Consequently, if these two quantities are known, their ratio can be found and from this the phase angle between the current and volts determined from a table of natural tangents. The cosine of this angle is the correct power factor and the sine is the reactive factor. For instance, if the watts in a circuit are 1,500 and the reactive volt-amperes are 1,089, then their ratio reactive volt-amperes $\div$ watts $= 1{,}089 \div 1{,}500 = 0.726$, which is the tangent of the angle of phase displacement. Locating this value in a table of natural tangents, we find the angle to be 36 deg. The cosine of this angle is 0.80, which is the power factor; the sine equals 0.588, and is the reactive factor. By using the kilowatt-hour and the reactive kilowatt-amperes-hour readings, in the same manner, the average power factor or reactive factor over a monthly period may be determined. Or if maximum-demand meters are used, the power factor and reactive factor at the time of maximum demand may be calculated. This is often of value in making a power-factor penalty charge.

In contradistinction to the two single-phase watt-hour meter method of determining power factor, which is applicable only to balanced circuits, the two polyphase watt-hour method will give a correctly weighted power factor regardless of any unbalancing in load.

There are, according to the *Electrical Review*, seventeen plants in operation in the Whittier district of California which remove water from crude petroleum by an electric process. The electrical dehydrator usually operates with single-phase alternating current at 11,000 volts. The emulsion of oil and water is passed between electrodes, and the effect of the electrostatic field is separately to coalesce the particles of water and oil. The water then settles readily by gravity. The average maximum demand per dehydrator is 4 kilowatts, the average load factor 50 per cent, and the average power factor 98 per cent leading. The oil treated ranges from 15 to 50 per cent of water, and the consumption of electrical energy is about 1 kw.-hr. per 18 bbl. of dry oil.

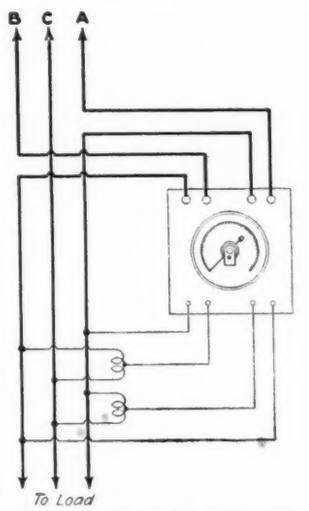


FIG. 6. WATTMETER CONNECTED TO A THREE-PHASE CIRCUIT TO MEASURE REACTIVE VOLT-AMPERES

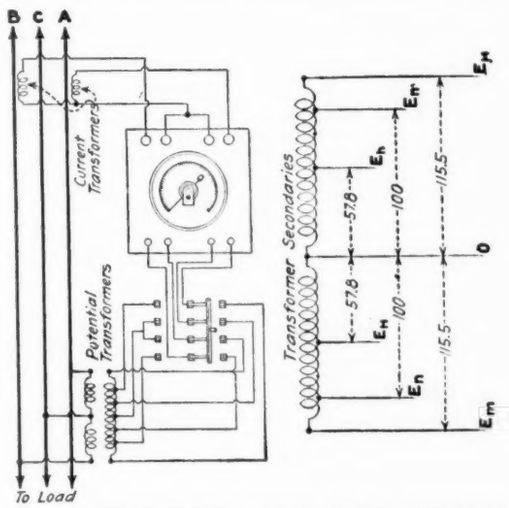
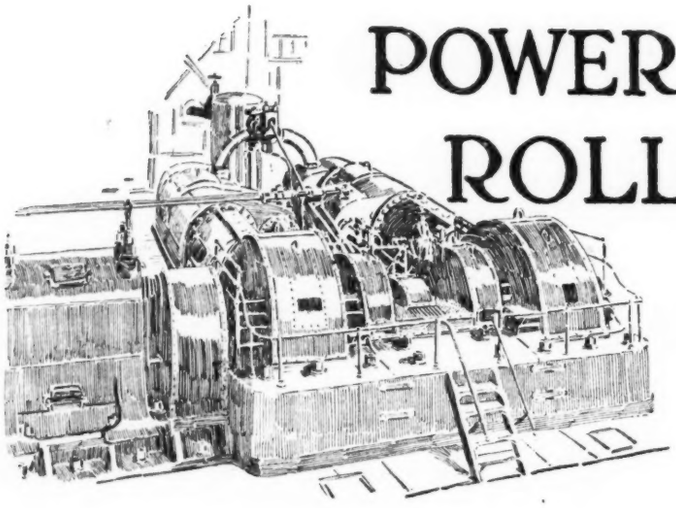


FIG. 7. WATTMETER CONNECTED THROUGH TRANSFORMER TO A THREE-PHASE CIRCUIT TO MEASURE REACTIVE VOLT-AMPERES



POWER DRIVES FOR ROLLING MILLS

By

W. O. ROGERS

Slide-valve, Corliss, poppet valve, tandem-compound and Cross-compound engines are used for driving rolling mills, and in one instance a mixed-pressure turbine was found in use. Some of these engines drive the rolls by means of belts, others through a train of gearing, and still others are directly connected to the rolls.

ROLLING-MILL engines are of various designs and cover the range from slide-valve units to Corliss, poppet-valve engines, and mixed-pressure turbines. A surprisingly large number of compound slide-valve engines were found, mostly ir the smaller mills and operating rolls that revolve in one direction only. Fig. 1 shows a Tod 16 and 30 x 30-in. tandem-compound engine, belt-driving an 8-in. mill at the Sharon Steel Hoop Co. The 24-in. wide belt drives a shaft that is connected to the bottom roll of the mill by a flexible coupling. The Tod engine has been quite popular around the Youngstown district, and many of them are in daily use at the present time. The smaller engines are fitted with flat valves as shown in Fig. 2. A peculiarity of the engine shown in Fig. 1 is the construction of the high-pressure cylinder. It is of the overhang type and is supported by the distance piece between it and the low-pressure cylinder, heavy ribs being cast on the flange and the cylinder to stiffen it. A shaft governor regulates the valve cutoff. These engines are generally equipped with a detachable reach rod for stopping and starting; the engines are of the side-crank type.

Various forms of drive between the engines and the mills are used. For instance, the engine shown in Fig. 1 drives the mill by means of a belt; the engine shown in Fig. 2 is directly connected to the rolls by means of a flexible coupling. Fig. 3 shows a 36 and 50 x 42-in. tamden-compound engine, fitted with piston valve. It is gear-connected to the rolls of a four-stand mill and also to a four-stand finishing mill by means of a belt.

On the engine shaft is a large gear which meshes with a smaller one in line with it and which drives one stand. The engine shaft drives a second stand, and a small gear on the engine shaft meshes with a large gear on a third shaft, which drives a third stand. This third-stand shaft also carries a small gear which meshes with a larger one on a fourth shaft, and this drives the fourth stand of rolls. In other words, the engine shaft is so geared that it drives not only its own stand of rolls but three other stands.

The steel bar enters the first set of rolls and the end is brought around to the second stand, the rolls of which run in a reverse direction, then through the third stand and finally through the fourth set of rolls. As every other set of rolls revolves in a different direction, the passage of the bar through the mill stands is in an opposite direction to the passage through the preceding set of rolls.

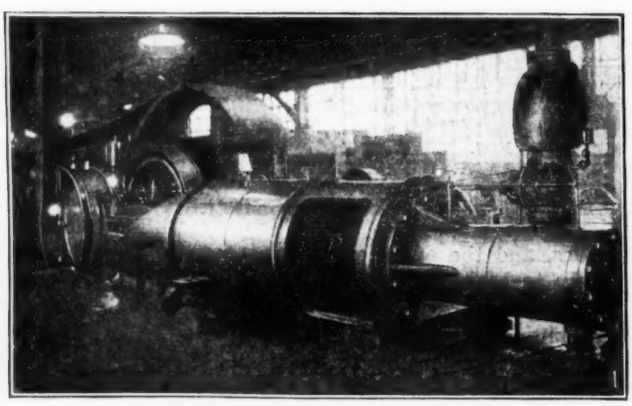


FIG. 1. TOD TANDEM COMPOUND ENGINE DRIVING 8-IN. MILL

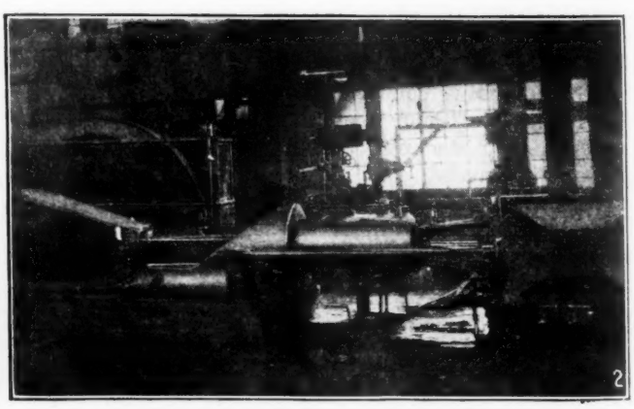
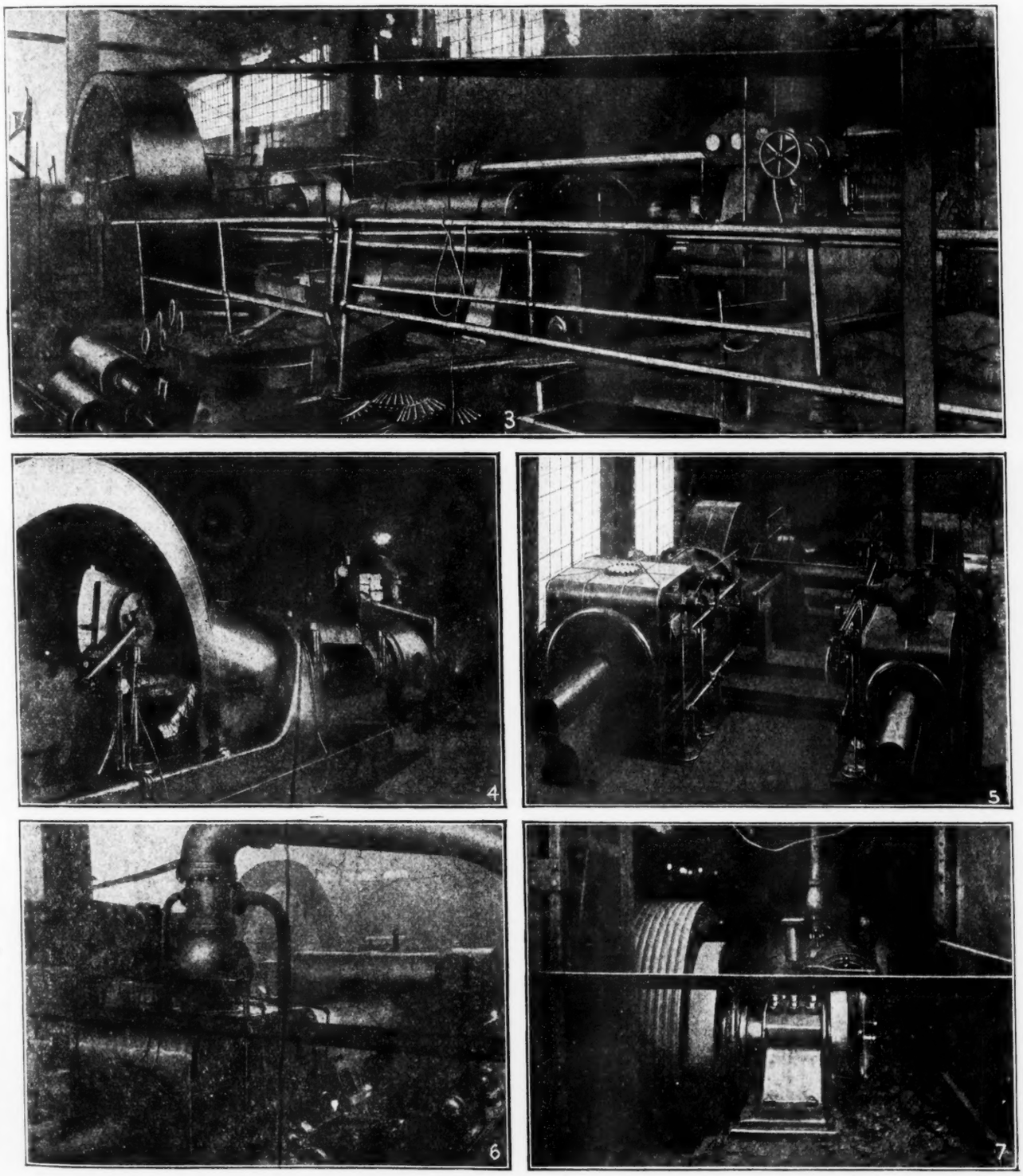


FIG. 2. VALVE SIDE OF A TOD ROLLING-MILL ENGINE

It looks simple to see the operator grab a moving mass of narrow sheet metal or a snake-like rod and steer it into its proper stand, but there is a knack in doing this work. The skilled operator does not attempt to pull the ends of the band or rod around in front of the stand, but grabs it with a pair of tongs and, as it comes through the preceding roll, simply arrests the end movement by drawing it to one side. When sufficient metal has passed through the roll to make a large U-shape, the end is directed to the stand to reduce the metal to a thinner piece, elongation taking place during the process. The man on the next stand performs the same trick and so on until the metal has been rolled to the required shape. An inexperienced man would make a sorry mess of the job, let alone the chances that he would be taken to a hospital for burn treatment.

At the Republic company's plant a tandem-compound Tod engine, Fig. 4, is used to drive a 90-in. plate mill,



FIGS. 3 TO 7. SHOWING VARIOUS TYPES OF ROLLING-MILL ENGINES

Fig. 3—A Tod tandem-compound, piston-valve engine, direct- and belt-connected to mill stands. Fig. 4—Tod tandem-compound engine driving an 18-21-in. billet mill. Fig. 5—A 6,000-hp. Mesta cross-compound engine driving a four-stand mill. Fig. 6—Another tandem-compound engine driving ten sheet mills. Fig. 7—A rope-drive unit, newly erected.

FIG. 8. GEAR ARRANGEMENT FOR DRIVING A FOUR-STAND MILL

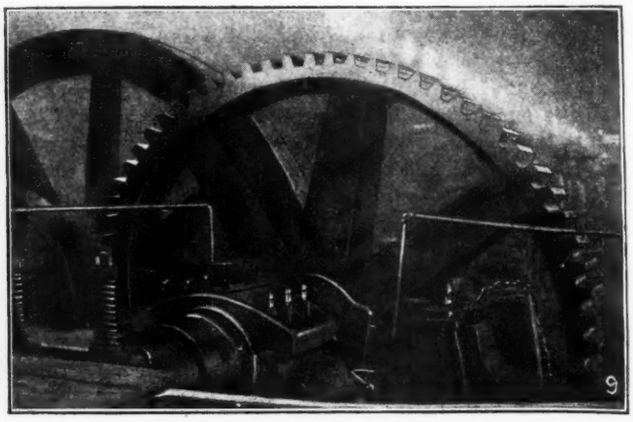


FIG. 9. GEAR REDUCTION BETWEEN ENGINE AND TIN-SHEET MILLS

but at the openhearth 18-21-in. billet mill a 48 and 84 x 60-in., 6,000-hp. Mesta cross-compound Corliss engine is used. This is shown in Fig. 5. A single eccentric operates on the high-pressure side, but two eccentrics are used on the low-pressure cylinder. The engine is coupled to a shaft on which beveled gears are secured, and these mesh with larger gears mounted on shafts that run at right angles to it and drive four stands of rolls. The gearing arrangement is shown in Fig. 8.

One of the largest engines I saw was at the Republic works. It was a twin-tandem-compound reversing engine of 25,000-hp. capacity. Another engine of the same capacity was found at the main plant of the Youngstown company, where a Mesta twin-tandem-compound engine (Fig. 11) is operating. It is, as shown, of extremely sturdy construction with a simple valve gear and a single lever control. The man standing by the engine gives some idea of the immense size of this unit. It drives a 44-in. blooming mill and has 46- and 76 x 60-in. cylinders. It has a maximum speed of 110 r.p.m.

The service of rolling-mill engines is most severe, and the spectator wonders how a machine can be made to operate without being disabled a dozen times a day. The full load comes on suddenly when the chunk of metal enters the roll and then leaves just as suddenly. One method of relieving the engine of the sudden strain and equalizing the variation of power is to use a heavy flywheel having a high rim speed and a sensitive governor on the engine. The flywheel is usually placed on the crankshaft to which the roll train is directly coupled. The weight of the flywheel depends, of course, on the size of the engine, but they will weigh up to 100 tons or more. A number of Porter-Allen engines were seen at various plants, and this engine is much used in the steel industry.

Reversing engines do not carry flywheels. They are compound units and are generally fitted with piston valves. The engine is directly coupled from the crankshaft to the roll train, but it is sometimes geared down to allow the engine to run at a higher speed than required by the rolls. Fig. 12 is a good illustration of a blooming mill and reversing engine. As will be seen, no flywheel is provided. The massive construction of the engine, coupling and mill gives at least a vague idea of the rough usage that is imposed on the machine but one must observe the work in order to obtain a clear idea of the tremendous shock to which the engine,

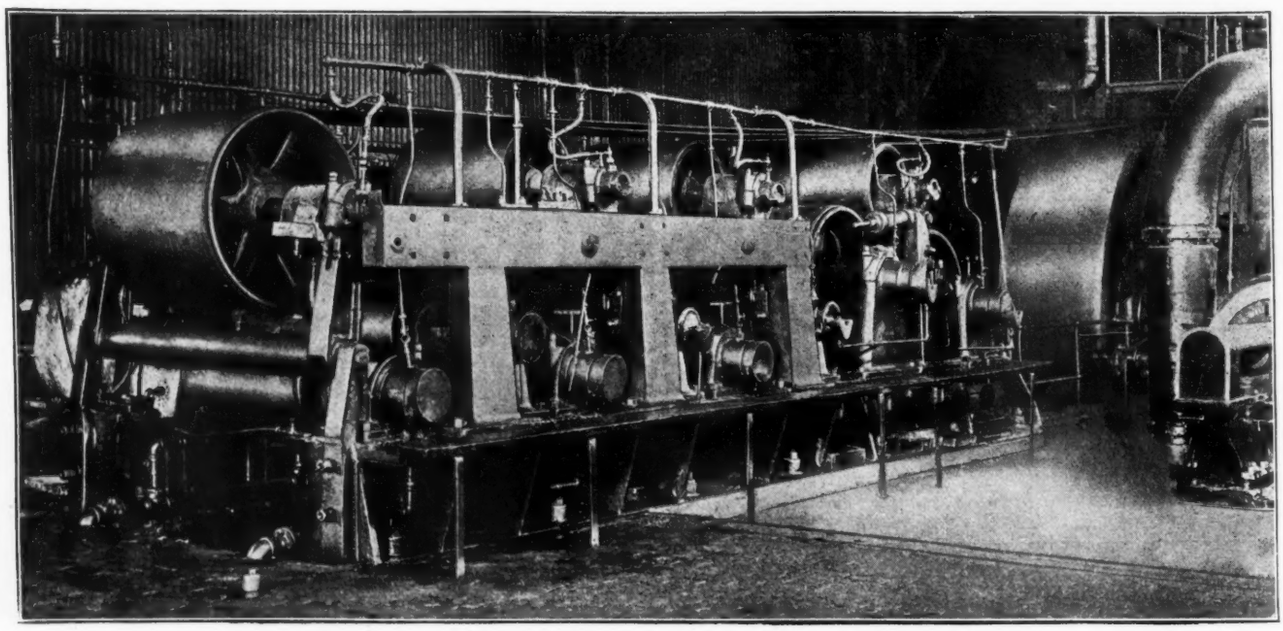


FIG. 10. STEEPLE-COMPOUND ENGINE DRIVING A 16-IN. ROD MILL BY MEANS OF FOUR 48-IN. BELTS

mill and bearings are subjected when in operation. Belt drives are not uncommon in the older and smaller mills. Fig. 10 shows an interesting installation and is out of the ordinary. The engine is a 34 and 64 x 48-in. steeple compound, rated at 2,500 hp. at 110 r.p.m. It is at the Struthers plant of the Youngstown Sheet and Tube Co., and operates a 16-stand rod mill by means of four 48-in. belts passing over the flywheel to as many driven pulleys. The engine also drives an air compressor. The path of the belts over the pulleys is easily traced.

The engine shown in Fig. 6 is a 34 and 68 x 60-in. tamden-compound Tod Corliss of 3,500-hp. capacity. It operates ten sheet mills at the Trumbull Steel Co.'s plant, Warren, Ohio. Engines engaged in operating sheet mills have a flywheel, but are geared to the mill so as to obtain the proper roll speed with the engine running at normal. A common method of reduction is shown in Fig. 9. A spur gear on the engine shaft meshes with a larger gear on the mill train. These mills run continuously in one direction and the passage of the sheets of metal on the return after passing through the rolls is either over the top roll or through the three-high stands. In the latter case the plate is rolled while going in both directions, whereas in the two-high stand mill the rolling process is in but one direction.

Rope drive is sometimes used. Fig. 7 is a view of a Tod 16 and 34 x 30-in. side-crank tandem-compound engine that has just been placed in position to be used in driving a 14-in. bar mill by means of a rope drive in conjunction with a 28½ and 54 x 40-in. Buckeye engine. The Tod engine will be belted to an idler shaft carrying a sheave wheel, and from there to the mill shaft, which carries a 28-ft. grooved flywheel. The large engine also belts to this wheel and runs over, the smaller engine running under. This arrangement was made because the larger engine was not of sufficient capacity for doing the work demanded of it.

It is not often that a direct-connected turbine is used for driving rolling mills, but this has been running for about five years in the plant of the Carpenter Steel Co., Reading, Pa. This unit is a 350-hp. mixed-pressure turbine and drives the mills through a double-reduction gear, the mill having two three-high 18-in. stands. This roughing mill was formerly driven by a 36 x 36-in. simple slide-valve engine. The turbine operates on exhaust steam from a 22 and 40 x 48-in. compound unit that formerly exhausted into a condenser. The original engine shaft and flywheel of the slide valve engine are used and the turbine speed of 5,000 r.p.m. is reduced by means of double-helical involute gears, first to 600 and then to 100 r.p.m. The speed of the rolls can be varied from 100 to 70 r.p.m.

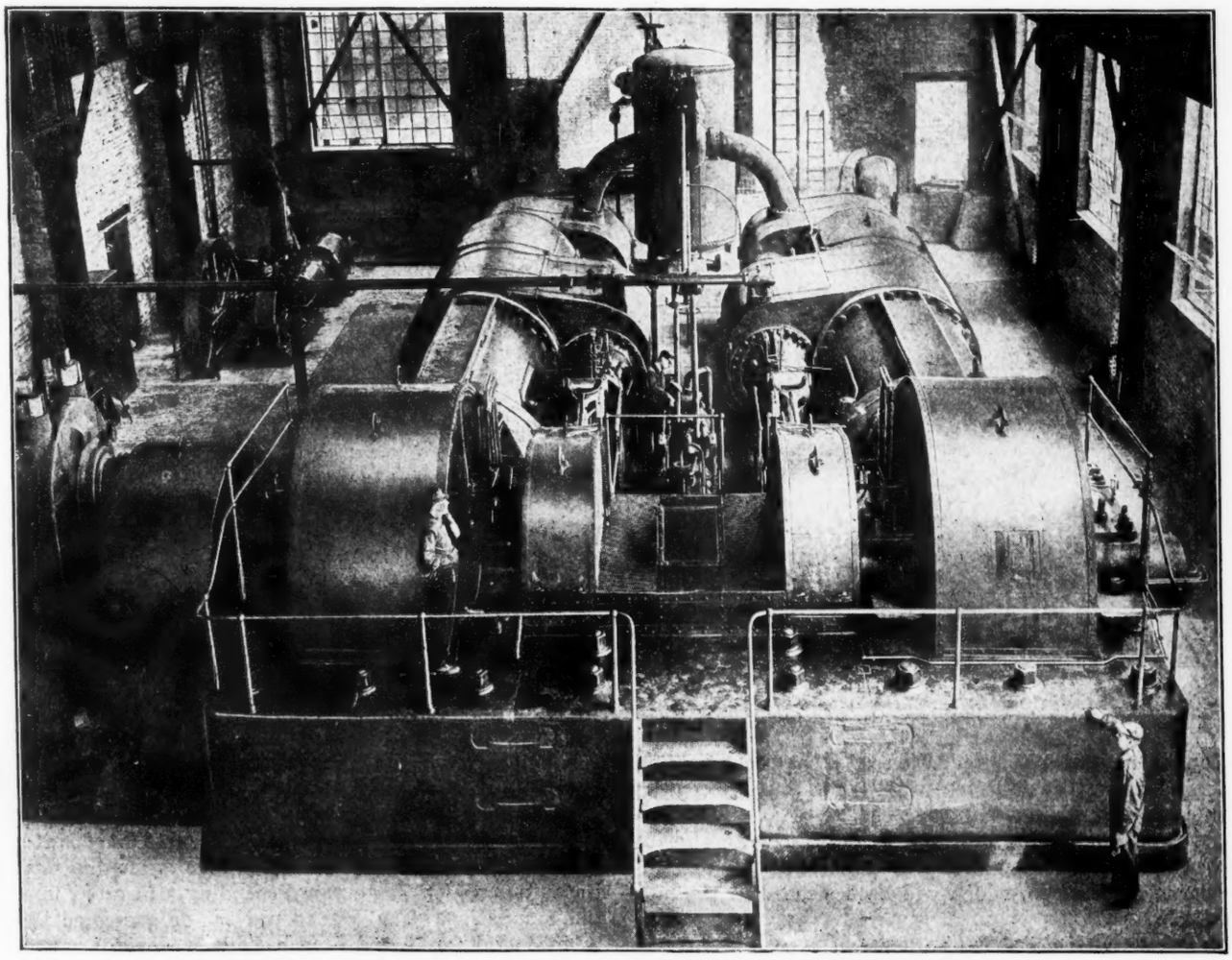


FIG. 11. MESTA 46 AND 76 BY 60-IN. TWIN-TANDEM-COMPOUND REVERSING ENGINE DRIVING A 44-IN. BLOOMING MILL

by means of a turbine governor that can be adjusted while the turbine is in operation.

The turbine operates normally at 3 lb. gage pressure at the throttle, and with 3 lb. absolute pressure in the turbine at the exhaust end, and under these conditions will carry its load of 358 hp. with a steam consumption of about 26 lb. per horsepower. The turbine can be run low-pressure condensing, mixed-pressure condensing, high-pressure condensing, or high-pressure noncondensing. Formerly, 1,000 hp. in boilers were necessary to operate the mill; with the turbine the boiler capacity has been cut to 600 boiler horsepower.

This is notable example of how increased power can be had with the reduction of steam consumption. This De Laval installation was the first in this country and the second in the world to apply a steam turbine for driving a rolling mill by means of reduction gears.

Another interesting mill drive was found in a uniflow-engine installation, which will be described in the next article.

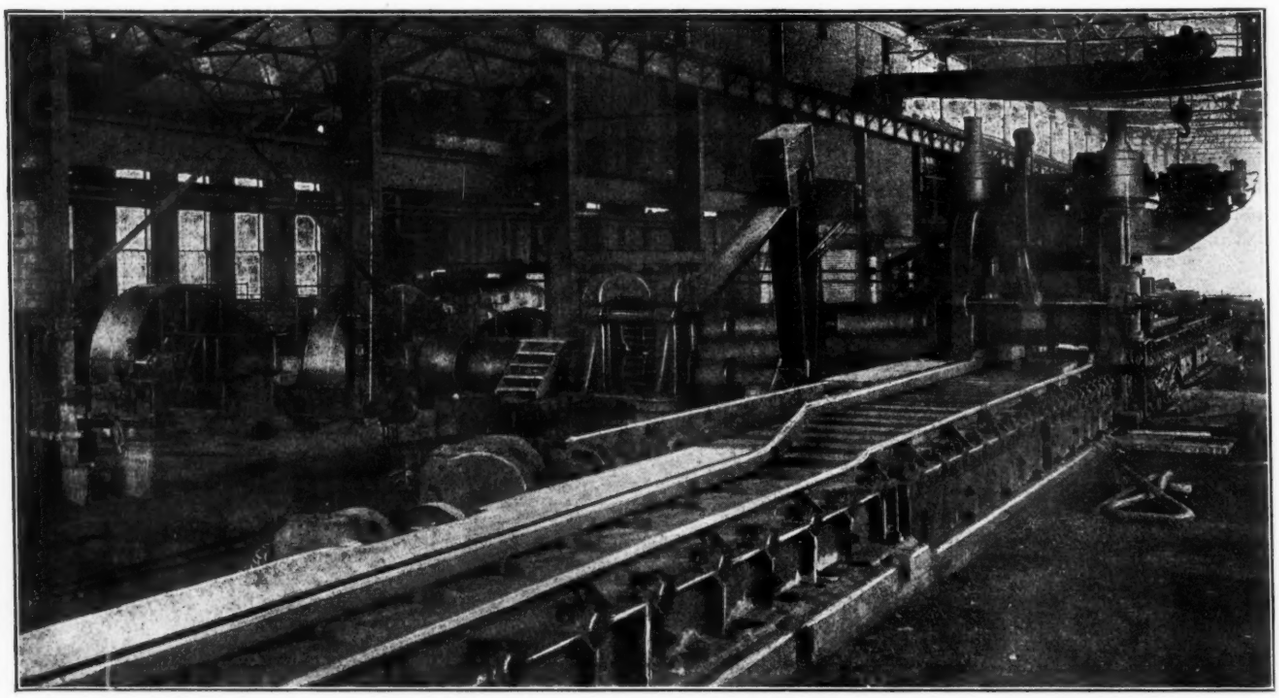


FIG. 12. COMPLETE BLOOMING MILL AND REVERSING ENGINE, OPERATING WITHOUT A FYLWHEEL

The Location and Remedy of Leaks in Rock-Filled Dams

BY ROLAND V. MCDONALD

While there are many water-power resources of large amounts of power, potentially, there are vastly more cases where the power is but small. Throughout Wisconsin and near-by states especially, the rock-filled dam is used to a considerable extent for the smaller hydro-electric and hydraulic plants for paper mills, etc., because it is easily built at low cost from materials near at hand. As more and more small hydro-electric plants spring up, utilizing a head of from a few to perhaps fifty feet and representing a capacity of from one hundred to several hundred horsepower, this type of dam may be expected to be used extensively. One of the troubles encountered with rock-filled dams, and more particularly with the older ones of industrial plants, is leakage. As this leakage may represent a large loss of water at a time when water should be conserved, and also somewhat of a danger, it is well to be able to locate and stop it.

Rock-filled dams are usually sheeted on the upstream side to make the dam free of leakage when first built, protect the filling or grout between rocks and reduce attrition and erosion due to the motion of the water. In course of time, this sheeting deteriorates and leakage through the dams finally takes place. This becomes worse and worse with time, as the water works a larger channel through the dam, carrying away filling and even the rocks themselves.

The remedy ordinarily is resheeting. If, however, the original sheeting was not driven down to hardpan or solid rock, leakage may seriously undermine the dam, the rate at which this occurs depending, of course, upon the foundation. The way to prevent or overcome this is to install an extra trench with a double row of sheeting driven well down so as to preclude leakage.

Leakage does not always occur at the dam, but, instead, may be discovered some distance away. Such leaks may form a regular subterranean tunnel and pass considerable quantities of water so that during periods when there is a shortage of water, the output of the plant may be threatened. The methods of locating depend upon the condition of the water above the dam, whether it is clear or turbid, smooth or rough. In all instances, however, some method of inspection and exploration is employed.

Where the velocity of the water is not high, the water smooth and clear, and not so deep but that the bottom of the stream can be seen, such holes can often be seen with the naked eye on a clear day. Sometimes a whirlpool action on the surface of smooth and comparatively

still water is the telltale. Conditions are rarely so favorable as this, however, and it is necessary to explore the bed of the river very carefully with an artificial light. This is best done by working the river transversely, back and forth as follows:

Sufficiently strong stakes are set in the ground, one on each side of the stream. To these a rope or cable is fastened. Two men in a boat hitch to the cross-river rope and work their way across the river from one bank to the other. The stakes and rope are then moved eight to ten feet up or down stream, and the boat is worked back to the other bank. This procedure is repeated until the entire river bottom for several hundred feet above the dam has been explored.

For the exploration the boat is equipped with an electric light of about 200 watts, obtaining its current from the station by flexible leads or from a storage battery. This lamp is, of course, inserted in a waterproof or marine socket fastened to the end of a rod of such length that it is capable of reaching the bottom of the river. One man then moves along the side of the boat with the light close to the river bed, while the other watches for eddy currents and signs of a suck-hole. The process is somewhat tedious where a large surface of river bed has to be explored, but it is very simple. As a precaution in case the lamp should be drawn into a suck-hole, a means should be provided for quickly disconnecting the lamp and feed wires. An ordinary bayonet plug fastened at the top end of the pole offers such a safeguard.

Where the water is turbulent and muddy, and too deep to permit the river bed being seen, a pole similar to the one already mentioned can be used, but instead of having a lamp fastened at the end, it will have a float or some object of such surface that the current of water pouring through the leak will suck it down into the hole. In this way the leak can be discovered without being seen. With the leak found, it then remains to determine its extent and shape, which can be accomplished by feeling it out with the light or float, as the case may be, the man who is watching making a mental note so as to determine the area of the opening.

With an idea formed as to the location and probable size of the leak, it is then feasible to prepare for filling in. The material used for filling depends upon the size of the subterranean tunnel. For a small channel small boulders suffice, and even bottles, while for larger channels sacks of cinders or concrete may be required. The best way of doing a good job and a permanent one is to start filling up with small stones, loaded tin cans, etc., until exploration with light or float shows that these obstructions are actually lodging and obstructing the flow. Then, a few sacks of cement or cinders can be let down on top until the suction has been practically eliminated.

A suck-hole or leak is always largest at its entrance. In filling it up, a space should be left on the river bed to permit sealing up with a good thick covering of concrete. This covering should be not less than two and preferably three feet thick, should cover a suface at least twice that of the leak and should be placed through a spot in the ordinary way.

Were a survey of river beds made as described, many of the older hydro-electric plants that now suffer from a water shortage seasonally, would probably find that they are losing considerable water through leakage.

Three Power-Plant Leaks That Waste Coal

By George H. Smith

Leaking steam traps, leaks at pipe points and uncovered steam pipes are three causes of wasted fuel that are often neglected. It needs only a few calculations to show how serious they usually are.

One way to test a trap for leakage is to open the discharge line near the trap. Any steam passing can then be easily detected. This test is not entirely satisfactory as the release of pressure will cause some of the water to flash into steam, thus making a perfectly tight trap appear to be leaking. A better test is to note whether the water in the gage-glass is always high enough to seal the discharge opening.

To form an idea of the loss from a leaking trap, assume that it is passing steam through an opening equal to a hole $\frac{1}{4}$ in. diameter and that the steam pressure is 80 lb. per sq.in. gage. The steam lost may be computed by Napier's formula,

$$G = \frac{ap}{70}$$

in which G = pounds of steam per second, p = absolute pressure in pounds per square inch and a = area of the opening in square inches.

Then $G = \frac{(80 + 14.7) \times 0.25 \times 0.25 \times 0.7854}{70} = 0.0664$ lb. per sec., which is equal to $0.0664 \times 3{,}600 = 239$ lb. per hour. Assume a boiler pressure of 90 lb. per sq.in., gage, a feed-water temperature of 120 deg. F., an over-all boiler efficiency of 70 per cent and that the coal has a heating value of 11,500 B.t.u. per lb. The heat lost per pound of steam is given by $H - t + 32$, in which H is the heat in the steam above water at 32 deg. F. and t is the temperature of feed water in degrees F. Then, since from the steam tables H at 90 lb. gage = 1,187.1, the heat lost per hour is $239\ (1{,}187.1 - 120 + 32) = 239 \times 1{,}099.1 = 262{,}685$ B.t.u.

The coal required per hour to furnish this wasted heat will be $\frac{262{,}685}{0.70 \times 11{,}500} = 32.6$ lb. If there are ten such traps, the total coal wasted would be 326 lb. per hour, or $326 \times 24 = 7{,}284$ lb. per day of 24 hours.

To get an idea of the loss from leaks at pipe joints assume a 4-in. line with the gasket blown out one-quarter way around a flange joint where the flanges are $\frac{1}{16}$ in. apart. With the same pressure as before Napier's formula will give

$$G = \frac{4 \times 3.1416 \times 0.25 \times 0.0625 \times 94.7}{70} = 0.264 \text{ lb. per sec.}$$

Using the same methods as above, the coal wasted by this one leak will be 3,110 lb. per day.

Now assume that there is a 20-ft. length of this 4-in. pipe uncovered. The area of radiating surface will be $\frac{4.5 \times 3.1416}{12} \times 20 = 23.55$ sq.ft. The temperature of the steam will be 324 deg. F., the room temperature may be assumed as 70 deg. F. and a heat loss of 3 B.t.u. per sq.ft. of surface per degree difference in temperature per hour is a reasonable value. The heat loss per hour from this bare pipe then will be $23.55 \times 3 \times (324 - 70) = 179{,}500$ B.t.u. Reducing this to coal per day gives 53.6 lb. from only 20 ft. of bare 4-in. pipe. Larger pipe and longer uncovered lengths will of course give correspondingly greater losses. A good pipe covering will save at least five-sixths of this loss.

Investigating Failure of Direct-Current Motors to Start

By E. C. PARHAM

Detailed explanation is given on how to make the tests necessary to treat the troubles in a direct-current motor that fails to start.

THE routine for locating trouble on a direct-current motor that fails to start, depends on the action of the motor up to the time of failure. It may be a new motor, or it may be a second-hand machine of unknown history. It may have given much trouble, or it may have given none at all; ultimate failure may have been suggested by gradual changes of speed, starting characteristics, sparking, heating or all of these combined; or failure apparently may have developed overnight and without demonstration. The location, duty or connections of the motor may have been changed, or the starter or some part of the motor may have been replaced. In many instances the trouble is not in the motor circuit, but is in the main circuit or in the connected mechanical load. This list of modifying influences suggests how helpful must be a knowledge of how the motor behaved before and when it failed. Such information, however, often is not available or is unreliable, therefore in this attempt to give a logical routine of procedure past actions will be disregarded and the history of the motor will begin with its failure. The starter will be assumed to be of the hand-operated type.

Assume the main circuit to be alive, as evidenced by the operating of other motors or of lamps from the same service. First look for a blown or otherwise defective fuse; an open or defective switch or circuit-breaker; poor contact of starter handle with the contact buttons. An open-circuit due to a fuse, a switch or a breaker may easily be located by means of a test-lamp circuit, as follows:

Fig. 1 shows the circuit in which the open is to be located. On holding the test lamp across 1 and 2 as indicated, the lamp should glow if the circuit is complete up to the fuses. This being so, on applying the lamp to 3 and 4 it will glow if the fuses or switch are not defective. Should 3 and 4 fail to light out, test across 5 and 6; glowing of the lamp means that the fuses are all right. If no light is obtained, test from 1 to 6 and from 2 to 5. If both tests fail to light out, both fuses are defective; when one test fails to light the lamp, the test lead that is on the motor side of the fuse will point to the defective fuse. After power has been found up to the switch, next test from 3 to 4. When light is obtained, the switch is all right.

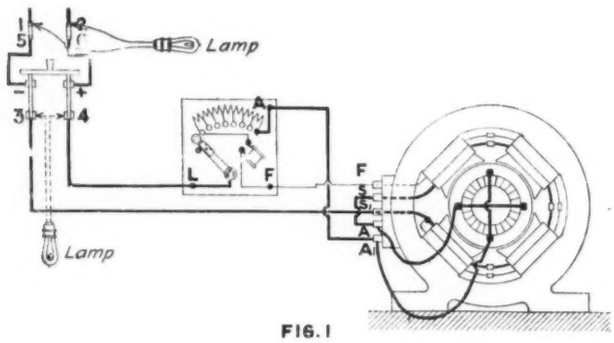


FIG. 1

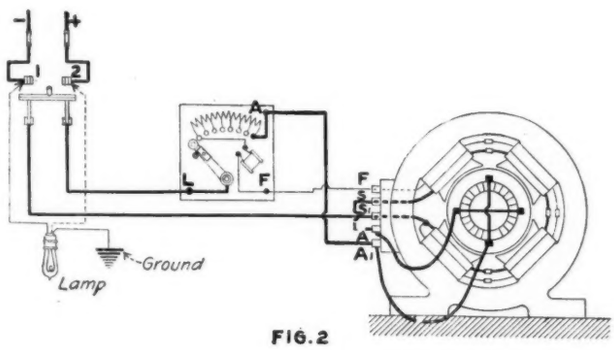


FIG. 2

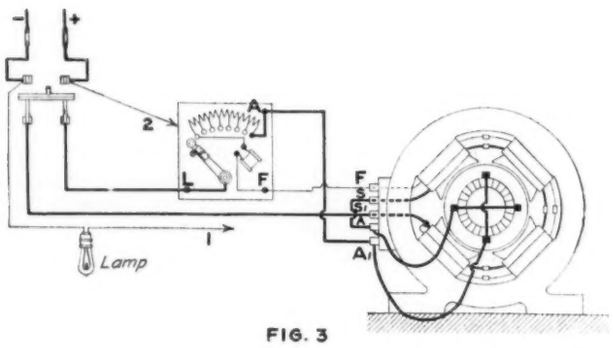


FIG. 3

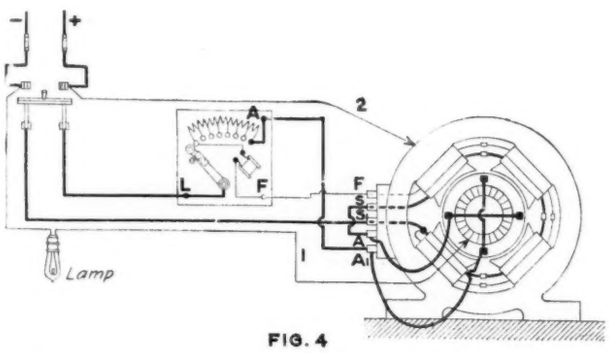


FIG. 4

FIGS. 1 TO 4. CONNECTIONS FOR LOCATING FAULTS ON DIRECT-CURRENT MOTORS

Note the nameplate of the motor and starter to see if they are adapted to each other and to existing line conditions. Inspect the motor, starter and connected load to see if the trouble may not be due to broken, burned off, pulled out, missing or wrong connection; missing, broken or tight, brushes, brush fingers resting on the holders instead of on the brushes; loose brush-holder yoke; grounded brush-holder studs; high

mica, worn bearings, obstruction in air-gap, armature rubbing polepieces, loose polepieces, loose bearing caps, or jamming of the connected mechanical load. Open the main switch and with a lamp-test circuit test the motor and starter for grounds, as follows:

Connect one end of the lamp circuit to one side of the line above the open switch, at 1 in Fig. 2, and touch the other end of the lamp circuit to ground—a conduit pipe, that is grounded, a steam pipe or a water

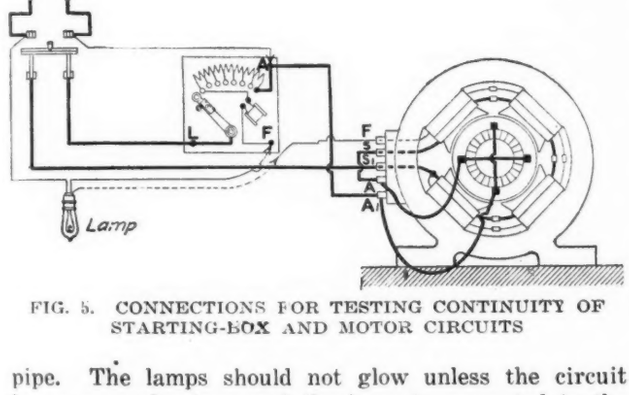


FIG. 5. CONNECTIONS FOR TESTING CONTINUITY OF STARTING-BOX AND MOTOR CIRCUITS

pipe. The lamps should not glow unless the circuit has a ground return and the lamp is connected to the ungrounded side. Next connect the lamp to the other side of the switch, as at 2, and repeat the test; if no light is obtained on either test, it means that the line itself is free of grounds. If one of the tests lights the lamp, however, it means that the opposite side of the line is grounded and the line end of the lamp circuit must remain connected to the side of the line that lights the lamps, when the other end of the lamp circuit is touched to ground. The other test lead is then connected to the other side of the line above the switch, thereby giving the complete connections of Fig. 3, which shows the starter and motor connections as well. In Fig. 3 the test circuit is properly connected for testing the starting box and motor, where the positive side of the line is grounded. With No. 2 test lead on the starting-box metal case, touch No. 1 lead to the starter handle and contacts; if the lamp glows, disconnect the motor from the starter and test again. A ground in the starter will be indicated by the lamp lighting; if it does not glow, the ground is in the motor circuit.

Assuming that the ground is in the motor circuit, raise the motor's brushes off the commutator and test the armature alone by touching No. 1 lead to the commutator and No. 2 lead to the frame, as in Fig. 4. If the armature is clear of grounds, disconnect the brush-holders, shunt-, series- and commutating-field circuits one at a time and test each separately. When a grounded field circuit is indicated, disconnect the coils and test one at a time to locate the grounded one. The same procedure must be observed in regard to the brush-holders. In the case of a compound machine test for a short-circuit between shunt- and series-field windings by first opening the normal connection between them, then hold No. 1 test lead on one terminal of one of the windings and No. 2 test lead on one terminal of the other winding. If the lamp lights, isolate the spools and test them one at a time.

Having failed to indicate a ground, restore all connections at the motor and open the field connection at the starter as in Fig. 5. With the starter in the off position terminal lugs *F* and *A* should light out through the starting resistance and no-voltage release coil, as also should the armature and shunt field when the test lamp is connected as indicated in Fig. 5. If no light is obtained, each of these windings and its connecting wires must be isolated and tested alone. When in doubt in regard to the starting box raise the panel and inspect the internal connections. Remember that a shunt on the series winding or on the commutating winding of the motor will make these circuits appear to be intact when in fact they may be open. Each pair of the starter contact buttons should light out excepting, in some cases, where several buttons on the "off" position end of the dial may not be used. In nine out of ten cases, inspection and lamp testing will locate the source of trouble. Where information is unreliable or unavailable, the preliminary tests are necessary; in all cases they are desirable, because they avoid abuse incident to the slam-bang method of trying the motor in order to see what happens. Another procedure that may be followed is:

Open the armature circuit at the starting box, as in Fig. 6. Then close the switch and jog the starter on and off; if there is no arc, there is an open either in the shunt-field circuit or in the main circuit which includes the fuses, the switch and the circuit-breaker and the starter handle and contacts. Look for poor or no contact between the handle and the buttons: the handle contact may have burned or may be missing entirely. If jogging the arm on and off the start position draws an arc, it indicates that the shunt-field circuit is intact. In order to be certain of this, however, tie the starter handle on the first notch, then feel the motor polepieces with a piece of iron to see if they are magnetized. If current is flowing in the field coils, all poles should attract the piece of iron with equal strength.

Next open the switch, throw the starter to the off position, restore the armature circuit to its original

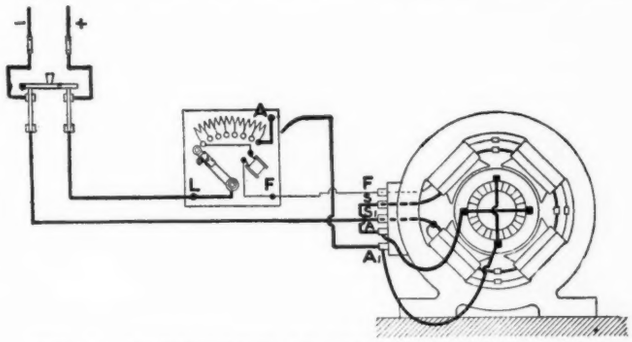


FIG. 6. CONNECTIONS OF COMPOUND MOTOR, WITH ARMATURE DISCONNECTED FROM STARTING BOX

condition and disconnect the mechanical load by removing the belt, pinion or coupling, as the case may be. See if the armature can be turned freely by hand and inspect the commutator for evidence of open-circuits or of short-circuits. Assuming that the commutator is normal, close the switch and jog the starter; if the arcing is no heavier than before, it means that the armature circuit is open; such an open may be readily located by the lamp test described in the foregoing. If, however, the arcing is much heavier than that due to opening the shunt-field circuit alone, it indicates the existence of motor trouble that the inspection and the lamp tests were not qualified to indicate, such as a reversed field coil or short-circuited armature.

Turn the armature a few degrees and again jog the starter; repeat it for several positions of the armature; if the armature will start from one position but not from others, indications point to internal faults. Next, repeat the test, but instead of shifting the armature, shift the brushes a few bars at a time until a whole pole-pitch has been traversed around the commutator. A loose brush-holder yoke will be dragged around by the commutator until the brushes reach a position in which the armature cannot be started.

Assuming the tests and trials to have resulted in starting the motor free, then, if the machine is compound wound, try starting the motor on the shunt field alone with the series winding short-circuited. Then try starting the motor on the series field alone with the shunt connection open at the starting box, in order to insure that the two fields are so connected as to turn the armature in the same direction. Opposition of the fields would not prevent starting the motor under no load, but it would prevent many motors from starting a connected load. Open the switch, connect the motor to its load, close the switch and start in the regular manner. If the motor starts, accelerates and operates without excessive sparking, after the best position of the brushes has been determined by trial, there will be nothing further to do. But if the brushes spark badly and it can be ascertained that the connected load is not too heavy for the motor to handle, the condition of the insulation of the wires of the field coils and of the armature should be thoroughly investigated. Especially is it important to do this if the motor is found to have been operating with the shunt windings and series windings opposed, because this condition results in a weakened field, an increased armature current and a consequent probability that the load has been sufficient to injure the insulation of all the windings.

In the large majority of cases the procedure outlined will result in the locating of the trouble. In an actual case of motor trouble, suggestive conditions will present themselves simultaneously and in almost every instance will obviate the necessity of doing a great deal of the work indicated. In exceptional cases failure may date from the installing of a new or a repaired armature, the winding or connections of which may be wrong. This should not be so puzzling, however, because in all cases where trouble dates from changes of any kind, the parts involved in the changes are a legitimate field of suspicion.

Refrigeration Study Course—VII. Insulation

By H. J. MACINTIRE

IN THE other parts of this study course the purpose has been to show the cycle used, the meaning of each part of the apparatus and its function in the cycle and the construction of the high- and low-pressure sides of the system. In other words, the production of refrigeration only has been considered. It is now appropriate that some time be devoted to the conservation of what has been produced by preventing, as far as possible, any leakage losses.

In general, it may be said that if two adjacent bodies have different temperatures, the tendency is for an average temperature to be formed. For example, the hotter substance tends to become cooler and the colder one to become warmer. The method by which this may be accomplished may be by radiation, convection or by conduction. *Radiation* is the method by which the sun's rays reach the earth or by which one receives the sensation of heat from an intense fire perhaps some distance away. *Convection* is the method by which heat is conveyed by a moving substance, like hot-air or hot-water heating in the factory or house. Finally, *conduction* is the manner in which heat is carried along by the particles (molecules) of a solid, as in the case of a hot slicing bar. In the case of refrigeration the heat comes from the atmospheric air as a rule, and passes into the rooms which are refrigerated or the insulated tanks or pipes.

The reason for the passage of heat from the air to the refrigerated pipes is self-evident on consideration of the conditions that prevail. Heat cannot run uphill. It passes, like water, from a condition of higher level to a lower one. The heat in the combustion chamber of a boiler passes through the tubes and shell into the (relatively) cold water in the boiler, and the flue gases are lowered in temperature and the water in the boiler is heated and evaporated into steam. And so it is that we try to protect the refrigerated system by insulation, as in the case of steam pipes or a boiler setting.

However, it is impossible to secure a perfect insulation, just as it is impossible to get perpetual motion or a 100 per cent conversion of energy. This is because we cannot find any substance that is a nonconductor of heat or that will entirely eliminate radiation and convection. So it is that the problem of insulation is one of securing a substance that is practical for our use, as regards price, ease of application and long life under working conditions, one that will decrease the losses to a minimum, remembering that the initial cost of the insulation varies directly with the thickness of the material, whereas the losses due to lack of more or less material are a maximum of the summer months only.

From the foregoing it may be seen that the problem narrows down to the following: To conserve refrigeration, insulation of a suitable material must be provided on all sides of the cold-storage room and on the brine and return ammonia pipe lines. Also that perfect insulation is impossible and that the proper amount and the kind of material to be used are dependent on conditions that prevail. These conditions vary with the average summer temperatures, with the kind of cold storage or refrigerating duty performed (and the length of this service) and the cost of a ton of refrigeration.

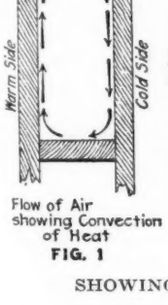
The Choice of an Insulating Material

The insulation material is really a part of the building construction, and it must therefore be on a par with the rest of the building. It must be capable of withstanding deterioration or rotting, and, in addition, should be free of odor of any sort. It should be capable of maintaining itself in position and not settle in places to leave pockets or air spaces. It must be waterproof so that moisture may not collect, thus tending to mold and to diminish its ability to insulate, and it must be verminproof. Finally, the insulator must be of a high degree of perfection and must be capable of reducing the heat losses.

The problem of insulation is much more difficult so far as moisture is concerned than is the case with steam. With steam the tendency is to dry out the covering and to maintain this dryness as long as the temperature of the steam is maintained inside the boiler or vessel. In refrigeration the opposite is true and moisture has a tendency to travel toward the coldest surfaces and to keep collecting as time elapses. In this case also it is possible to have ice form, which may loosen or disintegrate the insulation.

Theory of Insulation

The theory of insulation is somewhat difficult to understand at first. According to this theory there is no material that resists heat perfectly. Remember that insulating for refrigeration purposes is preventing



Flow of Air showing Convection of Heat

FIG. 1

FIG. 2

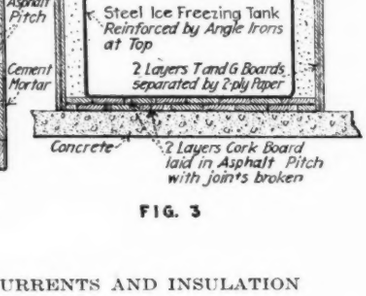

Cork Board
Asphalt Pitch
Cement Mortar
Granulated Cork
Steel Ice Freezing Tank Reinforced by Angle Irons at Top
2 Layers T and G Boards separated by 2-ply Paper
Concrete
2 Layers Cork Board laid in Asphalt Pitch with joints broken

FIG. 3

SHOWING AIR CURRENTS AND INSULATION

heat from coming inward from the atmosphere to the region maintained at a temperature which is *below* its surroundings. However, it is found that air pockets of extremely small size are an insulation, and any material which has the greatest number of these pockets is the best insulation, but each pocket must be separated from its neighbor. If the pockets were connected, then convection could take place as in the case of a hot-air furnace. From this it would naturally follow that the material that is the best insulator is also the *lightest* in point of *weight*, as a large amount of its volume is air. This is the reason that substances like mineral and animal wool, corkboard, balsa wood, shavings and sawdust have insulation values.

The use of air spaces naturally follows from what has just been said. However, it can be proved that large air spaces have little value. The reason is self-evident from Fig. 1, which shows the flow of currents of air from the colder to the warmer side of the insulation. Therefore, a partition made up of alternate courses of lumber and air spaces is uneconomical of building space.

Sawdust and shavings were used extensively at one time and still have certain advantages. They are not waterproof nor are they vermin- or fire-proof. They lend themselves to cheap temporary construction, such as ice storage buildings or wooden buildings put up for a short life or for short refrigerating periods. The work should be carefully performed, and the shavings or sawdust should be carefully packed and a waterproof paper very carefully secured in place. Sawdust is likely to settle and leave a space in the upper part of the wall, so shavings, dried before using, are preferred.

Lately, for second-class construction, a large number of special materials have appeared in the form of convenient-sized boards. These are compressed wood and vegetable fibers so devised that the board may be erected like lumber and nailed into place. Being compressed, it has the characteristics of shavings and has the advantage of more efficient insulation and being able to retain its position. It is not vermin-, fire- or water-proof, and so it would generally be used only in wooden constructions.

Some success has been achieved in the use of mineral wool, the product of blast-furnace slag or of special mineral earths. These are made up in the form of boards and attempts are made to waterproof the material in the process of manufacture. When so done, it is easily erected in place, is fireproof and a good insulator. It is used in permanent construction and should maintain itself for years.

By far the most successful and popular insulating material is cork, obtained from the bark of trees found principally in Spain and Portugal. This bark has the air-cell construction which is necessary for the use we desire of it. For refrigeration use is made of the wastage in the manufacture of cork stoppers, etc. The cork particles are compressed and heated so that they adhere together and are made up into boards of convenient sizes or in forms to fit standard pipes or tanks. The cork is inherently waterproof, and in erecting the joints and courses are made up in asphalt pitch. In building construction there is also a final coat, as a rule, of cement plaster, which protects the corkboard and gives a smooth surface for suitable cleaning.

Special kinds of work also use granulated or pulverized cork, as in insulating the sides of ice-making tanks or the ends of cylindrical tanks. Usually, granulated cork should be used only where access is readily obtained to repack from time to time should settlement occur.

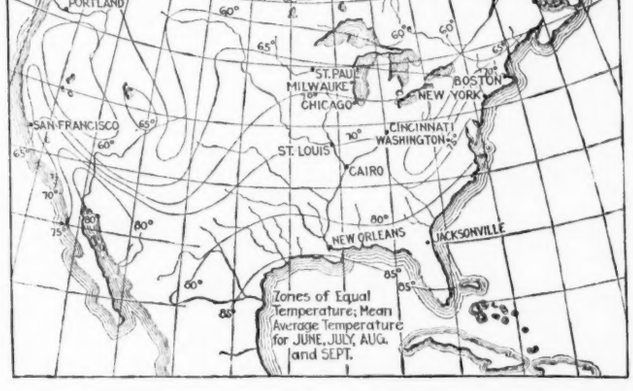


FIG. 4. SHOWING THE VARIOUS SUMMER-TEMPERATURE BELTS IN THE UNITED STATES

Insulation Values of Building Materials

Lately, numerous attempts have been made to find a suitable and correct method of figuring the insulating value of building materials. Elaborate experiments have been made, both with simple materials and with built-up construction. In these experiments it has been shown that there is on all material a "skin effect" which increases the insulating value. However, this is a matter that affects only the outside material, which for good insulation is usually cement mortar, or

otherwise, perhaps, tongued-and-grooved lumber or brick. The real insulating material is neither of these.

Neglecting the skin effect, the insulating value of the material used is dependent on its conductivity. By this is meant the number of heat units that will pass through it, usually rated on each square foot, one inch thick, per hour or per 24 hours with a difference in temperature on each side of the insulation of 1 deg. F. If this "leakage" is known for 1 deg. difference, then the leakage loss will be proportionately greater for 25, 50, 75 or 100 deg. F. difference in temperature. Likewise, if a material 1 in. thick will give a certain leakage loss, then one 2 or 6 in. will give proportionately less loss. This can be expressed in the formula:

$$Q = A \times K \times (t_{outside} - t_{inside})$$

where A equals area of wall or pipe surface in square feet, K equals conductivity, and t equals temperature in degrees F.

The value of K is obtained from tables of experimental values, as given below, or if use is made of several substances by the formula,

$$K = \frac{1}{\frac{T_1}{C_1} + \frac{T_2}{C_2} + \frac{T_3}{C_3} + ETC.}$$

where T_1, T_2, etc., equal thickness of each material in inches, and C_1, C_2, etc., represent conductivity as given in the tables for standard conditions.

Calculations: As an example of the use of the formulas, suppose a wall composed of 8 in. of brick, 2 in. board and ½ in. mortar is exposed to temperatures of 75 deg. and zero degree F. on the two sides and it is desired to find the leakage per twenty-four hours for a total surface of 700 sq.ft.

The value of K becomes (see values in table)

$$K = \frac{1}{\frac{8}{4.66} + \frac{2}{0.31} + \frac{\frac{1}{2}}{0.63}} = 0.111 \text{ B.t.u. per hour}$$

and the leakage is

$Q = 700 \times 0.111 \times (70 - 0) = 5{,}400$ B.t.u. per hour.

Whereas the skin effect would tend to reduce the value of K and Q, yet the factor which is important is the perfection of the erection, which is subject to wide variations. Unless the joints are carefully made and air-tight, moisture will get in and freeze, causing the ultimate deterioration of the insulation. This is probably the factor most responsible for the fact that the laboratory results and the practical results do not agree, and we are justified in adding a liberal factor of safety to insure good operating results. For these reasons and for simplicity of calculation it is recommended that use be made of the method of calculation as given.

As regards the maximum temperature to be used in the calculation of leakage losses, it is customary to assume an average maximum temperature during the period of peak refrigerating loads. Some idea of average temperatures in the United States may be obtained from the map taken from United States Government reports, Fig. 4. It is not recommended that the highest local temperatures be taken, but the average temperature experienced during the twenty-four hours for conditions that are likely to prevail for a period of days or a week or more. Of course the actual choice of the thickness of insulation for any particular case will be decided by the relative costs of the insulation itself and the book value of a ton of refrigeration. If the time of operation, days per year, is small, then one cannot economically install heavy first-cost construction. It would be too much like spending two dollars to save one dollar.

In conclusion, it is worth while putting special stress on the fact that the insulation must be kept dry, it must be kept in place and should be odorless. It should be easily placed in position and be of a material of economical insulating value.

REPORT OF TESTS CONDUCTED BY THE UNITED STATES BUREAU OF STANDARDS, WASHINGTON, D. C., COVERING THERMAL CONDUCTIVITIES OF VARIOUS INSULATING MATERIALS

Material	Conductivity 24-Hr. Ft.-Sq. In. Thick Deg. F.	Density	Nature of Material
Air	4.0	.....	Horiz. layer heated from above radiation
Colorax	5.3	0.064	Fluffy finely divided mineral matter (elim.)
Hair felt	5.9	0.27	
Keystone hair	6.5	0.30	Hairfelt confined between layers building paper
Pure wool	5.8	0.107	Firmly packed
Pure wool	5.8	0.102	Firmly packed
Pure wool	6.3	0.061	Loosely packed
Pure wool	7.0	0.039	Very loosely packed
Cotton wool	7.0	0.000	Firmly packed
Insulite	7.1	0.19	Pressed wood pulp—rigid, fairly strong
Linofelt	7.2	0.18	Vegetable fiber confined between layers paper—soft and flexible
Corkboard (pure)	7.4	0.18	
Eelgrass	7.7	0.25	Inclosed in burlap
Flaxlinum	7.9	0.18	Vegetable fibers—firm and flexible
Fibrofelt	7.9	0.18	Vegetable fibers—firm and flexible
Rock cork	8.3	0.33	Prest rock wool with binder—rigid
Balsa wood	8.3	0.12	Very light and soft
Waterproof lith	9.8	0.27	Rock wool, vegetable fiber and binder, not flexed
Pulp board	10.4	.....	Stiff pasteboard
Air cell ½-inch	10.7	0.14	Corrugated asbestos paper, inclosing air spaces
Air cell 1-inch	11.5	0.14	Corrugated asbestos paper, inclosing air spaces
Asbestos paper	11.8	0.50	Fairly firm but easily broken
Infusorial earth	13.9	0.69	(Block)
Fire felt (sheet)	14.3	0.42	Asbestos sheet coated with cement—rigid
Fire felt (roll)	15.3	0.68	Soft, flexible asbestos
3-ply Regal roofing	16.7	0.88	Flexible tar roofing
Asbestos mill board	20.2	0.97	Prest asbestos, fairly firm, easily broken
Woods—Kiln Dried			
Cypress	16.0	0.46	
White pine	19.0	p.50	
Mahogany	22.0	0.55	
Virginia pine	23.0	0.55	
Oak	24.0	0.61	
Hard maple	27.0	0.71	
Asbestos wood (sanded)	65.0	1.97	Asbestos and cement—very hard and rigid

NOTE.—The findings of the Bureau as outlined above were recommended for the guidance of the members of the American Society of Refrigerating Engineers by its Insulation Committee.

Statistics of petroleum production in states east of California during January and February, 1920, collected from data on file with the United States Geological Survey, show the quantity of oil received from producers by pipe lines and by refineries that receive petroleum directly from the well. In January Oklahoma led with a total production of 7,958,000 bbl., and in February 7,942,000 bbl. was produced. The daily average production in January was 256,710 bbl. and in February 273,862 bbl. Texas is second in petroleum production, followed by Kansas, Louisiana and Wyoming.

Geologists in the service of the United States Geological Survey, Department of the Interior, during the last four years have been investigating the geologic structure of parts of New Mexico with a view to determining the possibility of oil and gas reservoirs in these regions. While little evidence of oil and gas has been discovered, indications are favorable and geological experts are of the opinion that if wells were sunk deep enough (2,000 to 3,000 ft.) oil might be found.

Details of the Waterbury Turbine Explosion

POWER is indebted to the *Travelers Standard* of January for further particulars about the steam-turbine explosion in Waterbury, Conn., briefly reported in the issue of Oct. 28—Nov. 4, 1919, p. 682. The explosion occurred at the power station of the Connecticut Light and Power Co. Two men were killed, one of them instantly, and ten others were more or less seriously injured. The property damage was large, and an unofficial estimate placed it at $100,000. Fig. 1 shows the generator end of the damaged turbine.

The power-generating equipment of this station consists of six direct-connected, turbine-driven, three-phase generators of various types and capacities, all generating current at 2,300 volts and 60 cycles. Steam is supplied by twenty-two water-tube boilers. The usual operating steam pressure is 190 lb., and the safety-valves are set at 200 lb. All the boilers are provided with nonreturn valves. At the time of the accident fourteen boilers were on the line and three others were carrying banked fires, but were not furnishing steam. Four of the six turbines were in operation, two being shut down. The exploded turbine had been in regular operation since its installation some eight or nine years ago. It was known as "No. 3" and drove a generator having a capacity of 3,000 kw. Its normal speed was 1,800 revolutions per minute.

The main-turbine shaft was 13 in. in diameter and was turned down to 7 in. in diameter at the governor end (see Fig. 5). Six steel wheels, each 48 in. in diameter, were keyed to the shaft (see Figs. 3 and 4). The outer face of each wheel was about 5½ in. wide and carried two rows of buckets. The turbine was equipped with a governor of the centrifugal type, which transmitted its motion by means of a connecting-rod to the valve mechanism, which in turn actuated ten steam valves. An emergency stop was also provided, and this was arranged to operate at about 8 per cent above normal speed, or at 1,944 r.p.m. This emergency stop was mounted on the turbine shaft and consisted of an unbalanced ring which revolved with the shaft. At normal speed the ring was held concentric with the shaft by means of springs, but in case of excessive speed the spring tension would be overcome by the centrifugal force of the unbalanced weight. This would result in closing the 8-in. main throttle valve. The generator was direct-connected to the turbine, the shafts of the turbine and generator being joined together by a coupling bolted with ten 2-in. bolts.

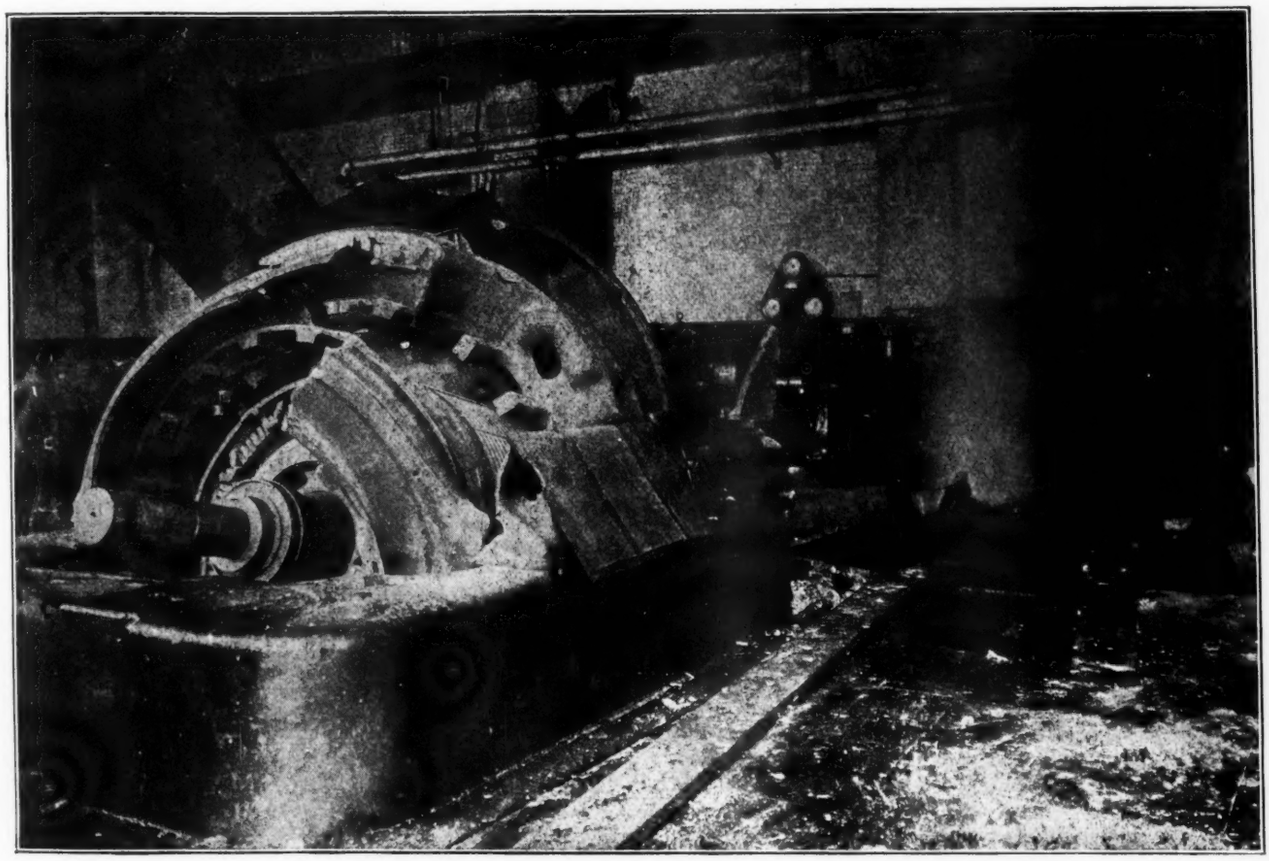


FIG. 1. THE GENERATOR END OF THE DAMAGED TURBINE AT WATERBURY, CONN.

The turbine shaft was broken in two places, and the bolts of the coupling also failed, permitting the two parts of the shaft to separate at this point, as shown in Fig. 2. This part of the shaft is 13 in. in diameter and about 6 ft. long and weighs approximately 2,700 lb. It was hurled over three of the turbines and, after passing through a window, came to rest in the yard outside of the power station, about one hundred feet from its original position. It will be seen that this part of the shaft was bent to an angle of about thirty

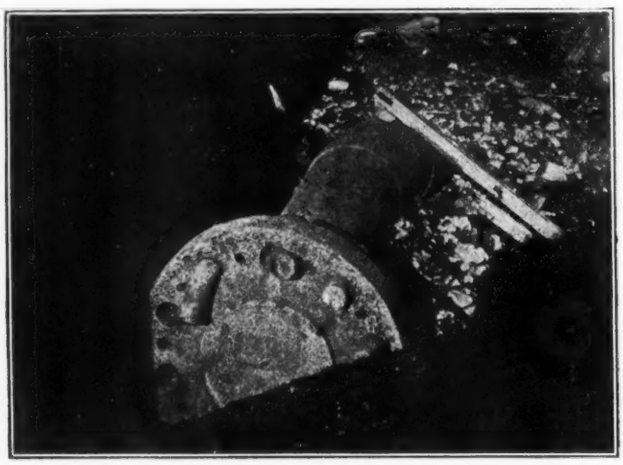


FIG. 2. PIECE OF THE TURBINE SHAFT

The piece is 13 in. in diameter and 6 ft. long and weighs about 2,700 lb. It was found 100 ft. from the damaged turbine. The piece is bent and the coupling bolts are bent and sheared.

large disc coming through the roof. He failed to see where the disc landed, however, because he started to run from the vicinity, believing that the entire power house was about to be blown up. Many other heavy parts were thrown in all directions, and some of them disabled the delicate mechanism of the other turbines and made it necessary to shut down the entire plant temporarily. The throttle valve of the damaged turbine is shown in Fig. 6.

Soon after the explosion an investigation was started to determine the cause of the accident. As usual in cases of this kind, various theories have been advanced, in support of each of which certain more or less important facts have been cited or suppositions made; nevertheless no one theory that has yet been offered appears to harmonize with all the known data. It is generally admitted, it is believed, that the exciting coils on all the four turbines that were in operation at the time became "dead" from some cause or other immediately before the explosion. The consequent loss of magnetism in the armature fields would prevent the machines from generating current and would therefore remove the load from the turbines and allow them

FIG. 3. THE BUCKETS WERE STRIPPED FROM THE WHEELS

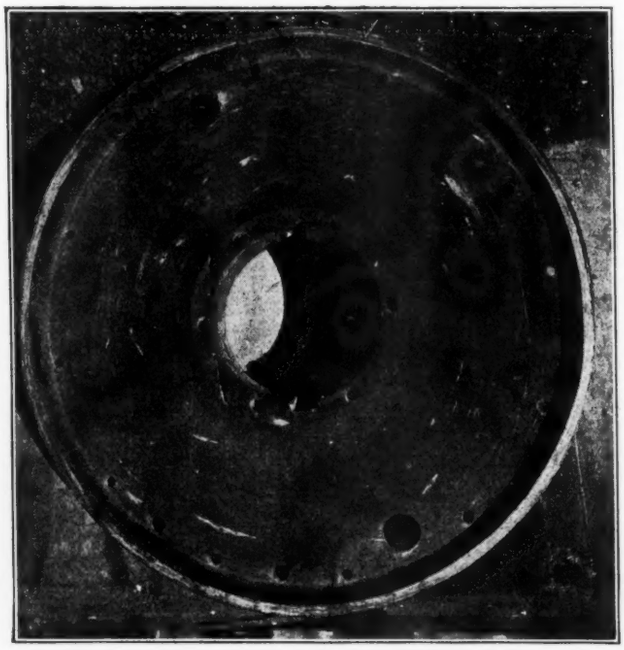


FIG. 4. A WHEEL APPARENTLY UNDAMAGED BY THE EXPLOSION

degrees. Another section of this shaft 6 ft. 4 in. long and 13 in. in diameter dropped below the floor of the turbine room. The piece here shown is 3 ft. long and 7 in. in diameter, and the break occurred at the point where the diameter of the shaft was reduced from 13 to 7 inches.

The wheels were thrown in all directions. Fig. 3 shows one of them from which the peripheral buckets were entirely stripped. Another wheel, shown in Fig. 4, is apparently intact. One of the wheels is supposed to have passed through the roof of the building and probably fell into the river near-by. This theory is based on the fact that only five wheels were found after the accident, although there had originally been six in the turbine, and that an eye witness, who was about 300 ft. from the power station when the explosion occurred, said that he saw a

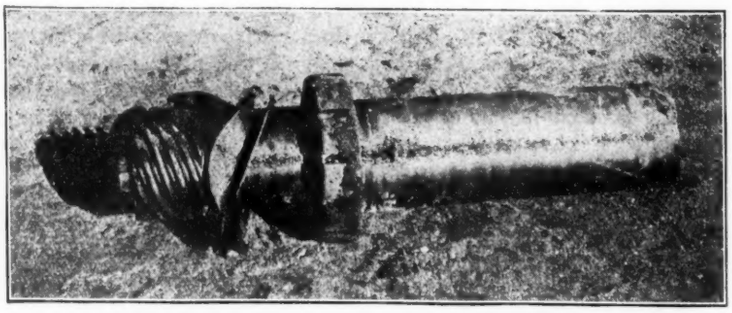


FIG. 5. PART OF THE GOVERNOR END OF THE TURBINE SHAFT

At this end the shaft is 7 in. in diameter. This broken piece is 3 ft. long.

to run free, subject to no restraint except the normal friction at the bearings and elsewhere. Increase of speed would be the immediate result, and it is evident that such an increase did actually occur. because three of the four machines running were shut down automatically by the operation of the emergency stops with which they were provided. The emergency stop on the machine that exploded also appears to have operated, and it happens that that particular stop had been tested only the day before and found to be in working condition. There is considerable difference of opinion, however, as to the extent to which the overspeeding of No. 3 turbine had progressed when the accident occurred, and it does not appear possible to decide this point in any definite and satisfactory way. The steam valve on No. 3 was found to be nearly closed after the accident, but for some reason or other it was not closed tightly. Possibly something had become lodged upon its seat. The theory that it stuck from some other cause appears to be almost disproved by the fact that it had worked freely and satisfactorily when it was tested, only twenty-four hours before. Whatever the real cause of the accident may have been, there is no evidence that can properly be construed as reflecting in any way upon

FIG. 6. THE THROTTLE VALVE OF THE EXPLODED TURBINE

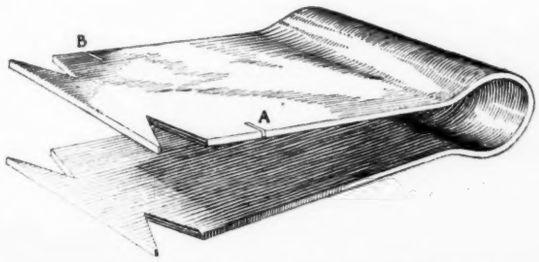
the Connecticut Light and Power Co., or upon the builders of the machine. It is hoped that further investigations will be made and the facts disclosed published, that appropriate measures may be taken to prevent similar accidents in the future.

The explosion resulted in the temporary suspension of power and lighting service in Waterbury and vicinity. Street cars were stalled, industrial plants were obliged to close down, and business houses, places of amusement and private homes were left in darkness. Local manufacturing plants and power stations in near-by cities were, fortunately, able to make emergency connections, so that the inconvenience to the public was of comparatively short duration. Furthermore, the damage to some of the remaining generating units was quite limited, and within a few days these had been repaired so that they could carry a considerable portion of the load.

Templet for Cutting Commutator Mica Segments

By W. A. Harris.

Commutator micas are usually cut by first laying one of the segments on a sheet of mica and marking out the desired form, after which the segment is cut out



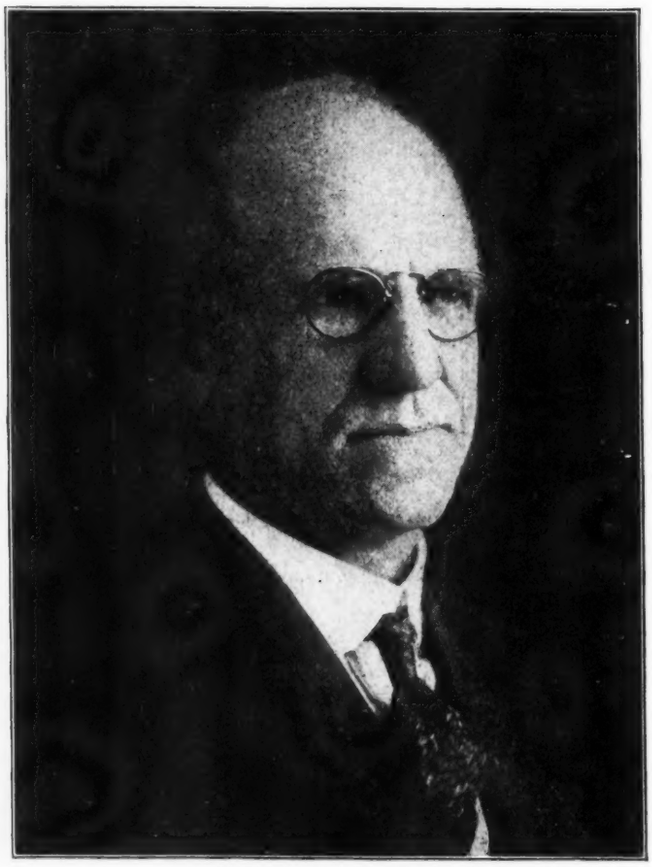
COMMUTATOR INSULATION SEGMENT TEMPLET

with a pair of shears. This method, even at the very best, does not produce segments that are of uniform shape. If a rigid construction of the commutator is to be obtained, not only must the insulating segments be of the proper thickness, but the V's in them must be uniform in shape and size as also the part of the segment on the inside of the commutator.

To obtain uniformity a templet, similar to that shown in the figure, may be used as a guide in cutting the segments. It is made of a piece of $\frac{1}{8}$-in. iron bent in the shape indicated. After this has been done the two sides of the templet are gripped in a vise and the V's cut the exact shape of those in the commutator for which the insulator is being cut. A notch is cut at *A* to indicate the maximum width of the mica and another at *B* to give the minimum width. The mica is cut to the approximate width of the segments, and then the templet is filled tight with these strips. While being held in a vise, the insulating segments are cut to the required shape with a hacksaw. A notch is cut in the mica at *A* and *B* to give the maximum and minimum width, so that after the segments are removed from the templet the excess material can be cut off with a pair of shears. The outside dimensions of the segments need only be approximate, since the excess material can be removed when the commutator is turned down.

The Board of Trade of Great Britain in a recent report shows that during 1919 approximately 104,000,000 gal. of petrol (gasoline) was imported from the United States. The report says that before the war the production of benzol was about 17,000,000 gal. per annum, and during the war it was increased to about 42,000,000 gal. of which some 32,000,000 gal. was produced by coke ovens and 10,000,000 gal. by gas works and tar distilleries. Since the war the output has fallen to about 25,000,000 gal. per annum.

A Veteran Engineering Research Worker



John R. Allen

A life dedicated to the investigation of heating and ventilating engineering problems. A successful organizer and teacher. Director of the Bureau of Research of the American Society of Heating and Ventilating Engineers

IT IS said that to few men are given the golden opportunity and ability to aid in the advancement of the human race through knowledge. Among these few will rank John R. Allen, of Pittsburgh, Pa., Director of the Research Bureau of the American Society of Heating and Ventilating Engineers. His life-work has been and is the advancement of engineering sciences through research and the promotion of engineering education. His efforts in this direction have yielded much that is proving beneficial, and his work is followed with keen interest by engineers and students of engineering alike.

Heating and ventilating engineering is comparatively young when measured by progress in other engineering lines, and modern heating and ventilating equipment is still far from perfect. A careful and exhaustive system of research might prove effective in clearing up some of the problems involved. Professor Allen, in his investigations at the University of Michigan and the University of Minnesota during the last fifteen years has done much for the advancement of this phase of engineering.

The United States Bureau of Mines, in a desire to coöperate with the Research Bureau, has placed at the disposal of Professor Allen and his assistants a portion of the magnificent laboratories at Pittsburgh, Pa., with their extensive equipment, and interesting developments which will prove of value to manufacturers and users of heating and ventilating apparatus are expected.

Some of the first things on which the efforts of the bureau will be centered are: The physical condition of the atmosphere which must be produced in order to maintain the same healthful effects as are obtained in pure fresh outdoor air; the scientific determination of heat losses by the use of various kinds of materials generally employed in building construction; the efficiency of various kinds of radiation; the most efficient methods of burning different kinds of coal, etc. This is only an outline of the questions that will be given immediate attention.

Many years of Professor Allen's life have been spent in teaching. His broad views and intensely human instincts, combined with a pleasing personality and unbounded enthusiasm for his work, have made him one of the most popular and successful teachers of engineering science in the country. Since his resignation from the University of Minnesota to take charge of the Research Bureau, students of the university have done everything in their power to induce him to return. Besides being a successful engineer and teacher, he is also a skilled organizer. During the years spent as research worker and teacher he has given to the profession two books—"Notes on Heating and Ventilating" and "Heating and Ventilation." These books contain a comprehensive account of heating and ventilating problems, experiments and discoveries.

Professor Allen was born in Milwaukee, July 23, 1869. He received a preparatory education at Milwaukee and at the Ann Arbor, Mich., High School, following which he entered the University of Michigan. In 1892 he graduated with the degree of B. S. and in 1896 he received his master's degree.

Following his graduation, Professor Allen took up his first position with the L. K. Comstock Construction Co., with which he remained for two years, and then he received an appointment as instructor in the Mechanical Engineering Department, University of Michigan. He was with the university from 1896 until 1911. His popularity with the students became so great and his ability as a teacher was so pronounced that he quickly advanced to assistant professor, junior professor and professor of mechanical engineering. In 1911 he resigned to carry out his plans for the construction and organization of Robert College, Constantinople, and until 1913 he was Dean of the Engineering Department. He returned to the University of Michigan after the completion of his work in Turkey, and for four years he was head of the mechanical engineering department.

In 1917 Professor Allen became Dean of the College of Engineering and Architecture, University of Minnesota, and remained there until 1919, when he was selected as director of the Bureau of Research of the American Society of Heating and Ventilating Engineers in coöperation with the United States Bureau of Mines.

He is an active member of many of the national engineering societies; past president of the American Society of Heating and Ventilating Engineers; past president of the Michigan Engineering Society; past president Michigan Chapter, American Society of Heating and Ventilating Engineers; president of the Minnesota Chapter of the American Society of Heating and Ventilating Engineers; honorary member of the National District Heating Association; member of the British Institute of Heating and Ventilating Engineers, of the American Society of Mechanical Engineers, the Society for the Promotion of Engineering Education and of the honorary societies, Tau Beta Pi and Sigma Psi.

Relative Value of Coal and Oil Fuel

Some Important Facts To Be Considered on the Advisability of Converting a Coal-Burning Power Plant to Fuel Oil

By GEORGE A. EVANS*

AT THE present time, owing to coal shortages and increasing prices of coal, a great deal of consideration is being given to fuel-oil burning. Notices are constantly appearing in the daily press of this or that plant having installed fuel-oil burning equipment in place of coal, and several articles have appeared in the technical press on the burning of fuel oil. It is the purpose of this article to analyze the various items that should be considered before such an important step is taken as changing from coal to oil fuel. The changing of ships from coal to oil is not considered here for the reason that conditions are so dissimilar that an entirely different analysis would be necessary.

Upon returning to the East coast recently, after having had the experience of operating with a fuel-oil plant in California, the writer was very enthusiastic on the subject of oil-fired boilers, owing to the great cleanliness of the fireroom, the absence of all coal-handling equipment with the accompanying dust or dirt, also the expense and disagreeable necessity of removing ashes. An investigation was made to determine and make recommendations as to the advisability of converting a certain plant from coal to oil fuel, and when all the facts of the case were carefully weighed, it was found that from an economical point of view oil could not be considered. This plant was equipped with six hand-fired-boilers, having a total boiler capacity of 2,250 rated boiler-horsepower, with a maximum station capacity of 4,200 kw. and the average output per month amounted to about one million kilowatt-hours.

On the accompanying chart is indicated the solution of a concrete problem according to the following assumptions: Efficiency of the boilers with coal, 65 per cent; oil, 75 per cent; the B.t.u. per pound of coal, 13,500; oil, 18,500.

Starting in the upper left-hand corner of the chart at a point indicating 18,500 B.t.u. per pound of oil, a line is drawn downward until it intercepts the diagonal line representing 13,500 B.t.u. per pound of coal. From this point the line is drawn to the upper right-hand chart intercepting the line representing 75 per cent boiler efficiency with fuel oil; from this point the line is drawn to the lower right-hand chart to the line representing 65 per cent boiler efficiency with coal, from which it is carried to the lower left-hand chart to a line marked $6 per long ton of coal. Continuing this line downward, it is found that the equivalent cost of oil in cents per gallon is 3.35c. That is, oil has to be purchased at 3.35c. per gallon, or $1.41 per barrel of 42 gallons, to be the equal in price of coal at $6 a long ton with the heating values and boiler efficiencies that have been assumed. By means of this chart any problem can readily be worked out to obtain the equivalent value of oil in cents per gallon for any price of coal for any combination of boiler efficiencies and heating values of coal and oil.

The chart makes no allowance whatever for the labor saving by using oil as a fuel. This saving is sometimes greatly exaggerated, and the small amount saved in labor is more than offset by the higher cost of oil. The saving in labor must be estimated for each individual plant, taking into consideration local conditions, cost of labor, etc. As a rule, higher-class firemen, which means higher wages, will be required to attend oil furnaces. In hand-fired boilers more labor can be saved, of course, than where the boilers are operated with stokers. It is doubtful if any reduction in the number of men can be made in a plant operating with stokers, nor can any reduction be made in a plant of one or two boilers employing one fireman for each watch. Where a battery of six or eight hand-fired boilers are converted to oil, the number of firemen could be reduced to one per watch, but no reduction in the watertenders or engineers of the plant should be figured on.

*Assistant to Mechanical Engineer, Public Service Electric Co., Newark, N. J.

The chart also makes no allowance for banking fires required with coal-burning boilers, an item not required with oil. The amount of coal used in banking must a'so be worked out for every plant, depending on its load conditions. Some plants operating twenty-four hours a day would use comparatively little coal for banking, while others operating with a day load would use a considerable amount.

Another factor often lost sight of in figuring on oil fuel is the amount of steam required for atomizing and heating the oil. A great majority of the power plants would undoubtedly use steam for atomizing in place of mechanical mixers. The amount of steam required for atomizing would be about 1½ per cent of the total amount of steam generated under daily average operating conditions and with a poor fireman might go to 4 or 5 per cent. With mechanical atomizing burners a higher efficiency can be obtained than with steam atomizers, but it often becomes necessary to change the boiler fronts and install blowers and air

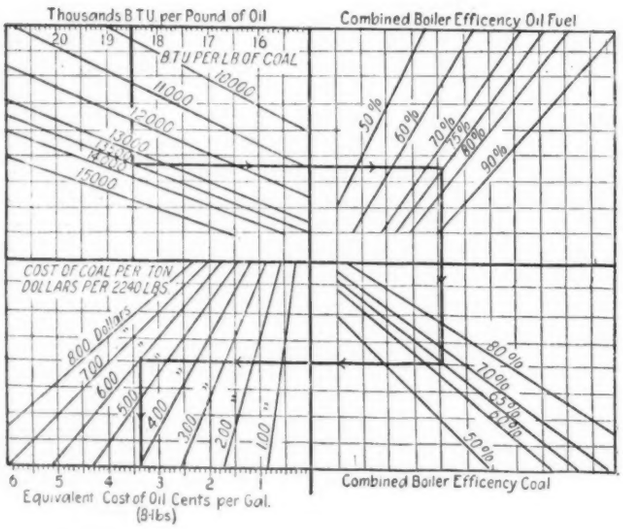


CHART FOR FINDING EQUIVALENT PRICES OF COAL AND FUEL OIL

ducts for forced draft. This, of course, would not be such a great item in a plant operating with stokers and forced draft, but as a modern power plant equipped with stokers operates at a boiler efficiency of from 70 to 75 per cent, very little can be gained by changing over to fuel oil.

If the furnace is not suitable, oil cannot be burned economically. On converting from coal to oil, in most boilers it will be necessary to set the bridge-wall back far enough so that the flame does not impinge on the wall of the furnace. The setting must also be high enough to give a good combustion space and to prevent the flame from impinging on the boiler tubes.

The question of the storage of oil must also be carefully looked into. It will likely be found that if a plant is in a congested locality only a limited amount of oil can be stored, and that in a tank placed underground or in a concrete pit. The capacity of this tank will depend on local conditions. Where there is room for outside storage if the tanks are placed underground 50 ft. away from a building, there can generally be unlimited storage capacity. If the tanks are placed above ground, the storage capacity is limited by the distance which the tanks can be placed away from the adjacent building. Starting with a minimum of 50 ft., the greater the distance the tanks can be placed from any building the larger the storage capacity allowed, depending on local laws and insurance rules.

The amount of storage capacity that can be made available is considered very important. Operating with coal, it has become the custom to have on hand anywhere from three to six months' supply. To store enough oil to operate a plant of any size from three to six months would take a considerable number of large oil tanks, create an extra fire hazard, also adding to the installation cost of the fuel-oil system. A fuel-oil plant will probably have to cut down its available fuel in storage to a month's or six weeks' supply. This point is important, as from past experience with car shortages and railroad delays it is not probable that a plant will have any more success in getting tank cars with fuel oil delivered to them than they have at present with coal cars. A plant situated on tidewater where oil can be delivered in tankers or bargeload lots would be more fortunate and also could get the lowest rate of oil. A plant that has to depend on tank cars pays a considerably higher rate than those on tidewater.

Referring again to the question of deliveries, there are comparatively few oil companies that can furnish oil in quantities to consumers, owing to the expensive equipment necessary, such as tankers, barges, tank cars and storage tanks. On the other hand, there are hundreds of coal mines within five hundred miles of this locality that can furnish coal.

Before an intelligent decision can be made on the question of installing oil in place of coal, the operating record of the plant for at least six months (a year would be better) should be known. The record should show the amount of coal consumed, heat units in the coal, pounds of water evaporated, the maximum load and the average load, as the results obtained in one plant cannot be used for comparison with another, since each plant presents problems of its own.

In conclusion the pertinent facts to be determined as to the advisability of making a change to fuel oil are results with coal, cost of installation, saving in labor, coal used in banking, steam used for auxiliaries as pumps, atomizing, heating, etc., suitability of furnace, means for storage and receiving of oil, and the price of coal and oil delivered to the plant, and the heat units in each.

In a series of tests to determine the steaming value of Alaska lignite and spruce wood and the resistance of lignite to weathering when stored in piles in the open, by the Fairbanks, Alaska, Station of the Bureau of Mines, the results showed that a cord of wood is equivalent to more than a ton of lignite. In the weathering test, which lasted fourteen months, that portion of the pile immediately exposed to the atmosphere was entirely disintegrated, while that farthest from the surface was only partly disintegrated.

It is necessary to properly pitch and drain pressure pipe lines with pipes of ample size to take care of the rapid condensation of the steam when first turned into the line. If traps are used, they should be located below the line to drain it dry when steam is shut off. It is good practice to put a bleeder on the end of the line farthest from the steam inlet to help remove the rapid condensation which is bound to take place when the steam is first turned on.

EDITORIALS

Hazards of the Human Element

HOW many, who are trusted with the operation of boilers, are in the habit of taking them out of service, washing, changing tubes and in other ways making repairs, and then placing them back in service and without watching the water column, taking heed of the pressure gage or determining the working of the safety valve? It would seem that under all conditions a boiler that has been out of service for any purpose should be blown down or in other ways treated to indicate the accuracy or at least the functioning of the water column and the pressure gage. Every engineer has some idea as to how long it takes any of his boilers to come up to normal pressure, and failure of the gage to register with the lapse of time should immediately lead to an investigation.

The incidents connected with the recent East Chicago fatality emphasize that external conditions may affect the safety of a boiler as much as the internal conditions—a fact well known but, unfortunately, not always appreciated. It was an external, even an extraneous, form of trouble that was directly responsible for the explosion, yet apparently this very potential danger had not been taken into consideration. Pressure gages had frozen before and at the time of the accident the temperature was about zero. For twelve years these boilers apparently had been exposed to the danger that finally wrecked the boiler house, killed three men and maimed a dozen. The danger was, therefore, an old one—it was only the materialization of this danger that was new.

The only conclusion possible is that the human element remains the least known quantity, the greatest variable and the most unreliable factor. The materials failed, but it was only after men had failed. The human element failed when safety valves and pressure gages were permitted to become frozen. The human element failed again when it was possible to continue firing up a boiler from nine in the evening until four-thirty in the morning, or seven and a half hours, when the behavior of the pressure gage should have made it conspicuously obvious that conditions were not as they should have been.

Materials and structures can be protected by ample factors of safety, but we can only alleviate, never eliminate, the vicissitudes and sporadic failures of the human element by proper training, wise education and ceaseless reiteration of the gospel of safety. Nowhere is this more true than in the boiler room. Do we not know of men who do not think? Of boiler-room instruments that are not earning dividends, because the men do not know how to use them? Where waste and loss and failures are rife because nobody cares or nobody remembers?

The responsibility for this rests, not upon the boiler-room force alone, but with those higher up, with civic authorities that permit stored energy comparable with dynamite to be housed unsafely and operated unwisely; with the insurance interests that sometimes are able to see only one side of the question; with the plant owner who so often can see neither side. State laws, boiler codes and civic statutes have gone a long way toward improving matters. But it requires tragedies like that at East Chicago to remind us that we have a long way to go yet to protect boilers from without as well as from within and to make working conditions safer for those within as well as those without.

Measuring Reactive Factor

MUCH has been written concerning the explanation and measurement of power factor and the deleterious effect of low power factor on an electric system. It is general practice to supply machines such as synchronous motors with power-factor meters so that their power factor may be adjusted to the desired value. Any deviation from unity power factor results in increased heating, but this heating is not proportional to the power factor; it is a function of the reactive factor, which is a ratio indicating more directly the heating effect to be expected. The power factor is the cosine of the phase angle between the current and voltage where the reactive factor is the sine of this angle.

Although a power-factor meter indicates the deviation from unity, and indirectly the excess heating, yet the psychological effect of using a reactive-factor meter is considerable on the machine attendant. For instance, if a synchronous motor is operating at ninety-five per cent power factor, the attendant may think this is only five per cent away from unity, and consequently good enough. But ninety-five per cent power factor is equal to thirty-one and five-tenths per cent reactive factor, and the attendant, seeing a reactive factor of thirty-one and five-tenths per cent on the meter, will usually make an effort to better conditions, although it is exactly the same in both cases, called by a different name.

A wattmeter, when connected into an alternating-current circuit, indicates watts, the product of the volts and energy component of the current. If the potential coil of the meter is excited with a voltage ninety degrees out of phase with the original volts, the meter will indicate the wattless or reactive-volt-ampere component. An important reason for measuring reactive volt-amperes is that the weighted power factor of an unbalanced three-phase circuit may be easily determined from the wattmeter and reactive volt-ampere meter readings. The cosine of the average angle of phase difference or the average power factor has very little meaning when a three-phase circuit becomes unbalanced unless, in the calculation, each phase is given a weight proportional to its load. The power factor determined by the foregoing method is this desired weighted value.

In an article entitled "Explanation and Measurement of Reactive Factor," in this issue the method of measuring reactive factor and also how to measure reactive volt-amperes are explained. Although this is not a new subject, it is only comparatively recently that the matter has been given much attention. As stated before, one of the reasons that attention is being focused on it

at this time is that it provides a means of obtaining the weighted power factor on an unbalanced polyphase circuit. It is becoming general practice for power companies to penalize their customers for power factors below a given value; integrating the reactive kilovolt-amperes as well as the kilowatts is one of the means employed to arrive at the average power factor over a given period, consequently it is of interest to the operating engineer that he become familiar with what reactive factor and reactive volt-amperes are and how these elements affect the operation of the power systems in their charge.

Not So Badly Off As We Might Be

WE are prone to complain of the lack of standardization in our electrical power systems, especially when the subject of interconnecting these systems is discussed. However, sixty and twenty-five cycles have become standard to a very large degree throughout this country, with some few exceptions where fifty or forty-cycle systems and other frequencies are in use. In few cases will more than two frequencies be found in the same locality. The power systems of the large cities are in general either sixty or twenty-five cycles, or both systems are used.

According to a report issued recently by the "Bureau of Foreign and Domestic Commerce, Department of Commerce," on the "British Industrial Reconstruction and Commercial Policies," there are seventy operating companies supplying power to the City of London, owning seventy different power plants, operating fifty different types of systems, having ten different frequencies and twenty-four different voltages. The electrical industry throughout England is so unorganized, according to this report, that one cannot purchase a simple lamp bulb without specifying the type of socket in which it is to be used. When the conditions existing in this country are compared with those in England, have we not good reason to consider ourselves fortunate?

Increasing Boiler Output

MANY operating engineers will be confronted next fall with a demand for greater capacity from their hand-fired boilers. Owners are reluctant to purchase new equipment at the present high prices, and an effort will therefore have to be made to obtain greater output from the boilers already installed. This will require the burning of more coal, but the chimney draft may not be sufficient to do this on the present grates, and the chimney may not be large enough to carry away the increased products of combustion with the draft that it is able of itself to create.

The real way to deal permanently with the situation is to install forced-draft mechanical stokers. A less expensive expedient, and one that may be practicable in cases where the stoker would not, is the installation of some sort of device or apparatus for increasing the draft. This may vary from jets of steam blown into the chimney, furnace or ashpit, to large and elaborate fan systems for forced or induced draft. One such device, capable of general application to existing plants without material modification and at small expense, is the turbine-driven undergrate blower. Several reliable makes are on the market. With a closed ashpit they can produce drafts up to four inches of water. Such a draft would allow the use of small and low-grade fuels or the combustion of a much greater amount of coal per square foot of grate than would be possible with natural draft. If the blower is operated to produce a balanced draft over the fire, the capacity of the chimney will be increased, for the natural draft will be available for carrying off the greater volume of waste gases. These blowers are substantially made with turbines, the nozzles of which are adapted to the conditions and may be automatically controlled to maintain a constant boiler pressure. The steam is used to advantage, and the exhaust is available for heating feed water and similar uses. The equipment is not expensive and can be installed in the average plant without difficulty and with little interruption to regular operation. Its use is suggested as a means of getting increased work out of existing equipment with little additional investment and with a moderate cost of maintenance.

We sympathize with the writer of "Random Reflections" in *The Engineer* (London) in his lament from a purely sentimental point of view at the substitution of steam turbines for reciprocating engines. Sentiment that interferes with progress has no place in engineering, but no one can say that the man who feels the fascination in watching the regular motion of a reciprocating engine is any poorer engineer because he regrets its passing. The turbine is a wonderful machine, but who would spends hours "watching its still casing or listening to its monotonous hum"? The big reciprocating engine is giving way to the turbine, but it will always leave a tender spot in the memory of the men who knew it.

Carbon tetrachloride has been suggested as a possible substitute for oil in high-voltage switches for a number of years past. However, its use has not met with much favor. It is understood that one large operating company is investigating the possibility of this substitute for oil in switches at the present time, the results of which will be looked forward to with much interest. Wherever oil is used, there is always a fire hazard. On the other hand, although carbon tetrachloride is not inflammable, it evaporates rapidly, is an anesthetic and a solvent of rubber. Any of these properties under certain conditions may be as objectionable as the inflammability of oil.

Isn't it about time to hear again from the man with the little bottle of green—or is it yellow?—liquid, one teaspoonful of which will make a gallon of water do more work than a gallon of gasoline. The price of gasoline is still going up, and the man who controls any of these wonderful substitutes should come to the rescue of the long-suffering public.

With the coming of warm weather it will be worth while to occasionally check up the viscosity of the oil in plants subject to hot bearings in summer.

Between silt and floating débris coming down with the flood waters hydro-electric plant engineers now have their hands full.

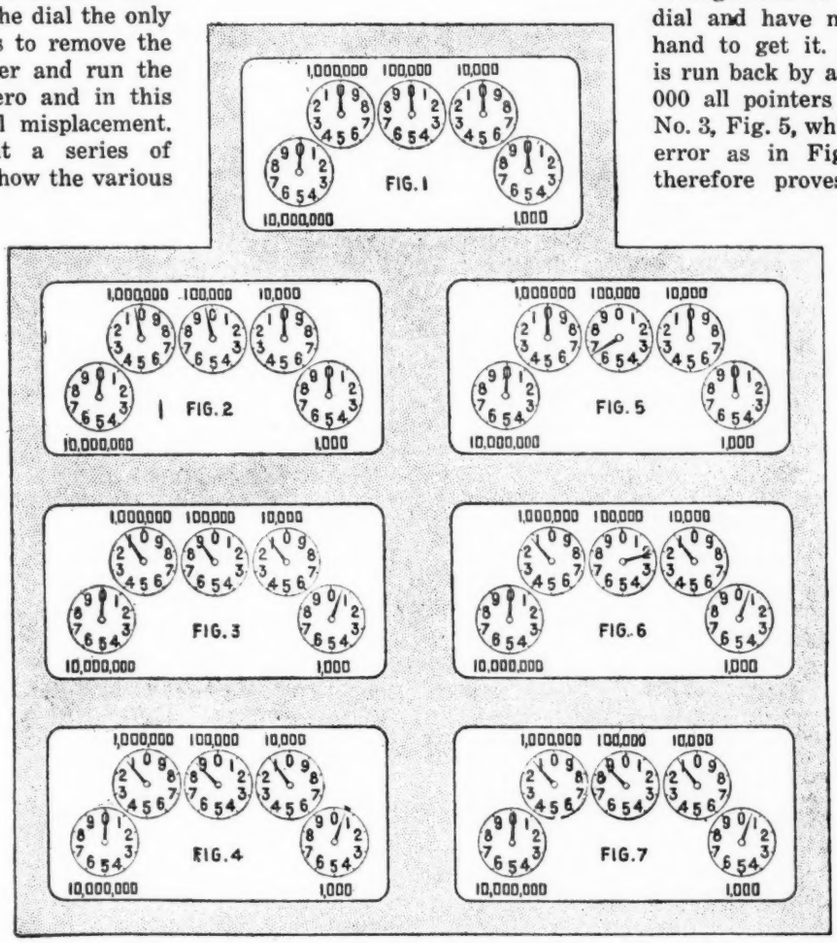
Unless it soon stops the price of rice coal will be as high as that of the cereal.

CORRESPONDENCE

What Does the Meter Read?

I have read the various solutions of A. A. Fredericks' meter problem, "What does the meter read?" in the Dec. 9, 1919, issue of *Power*, with much interest, and the majority of readings would indicate that the correct answer is 0,091,000. However, this is only half the story, for in the case of misplaced pointers on the dial the only proof of the case is to remove the dials from the meter and run the pointers back to zero and in this way find the actual misplacement. I herewith present a series of meter dials which show the various steps tried with a dial and which will be of interest to those who do not happen to have a dial at hand. The location of the pointers, Figs. 2 to 4, proves 0,091,000 to be the correct solution of the problem given to Mr. Fredericks. Figs. 5 to 7 show pointers proving my solution 0,121,000 to be correct, with the pointer also placed as given in Mr. Fredericks' dial. In Fig. 1 all pointers are on 0 and correctly placed. The dial, Fig. 3, gives 0,091,000 as the reading with hands correctly located. Fig. 6 shows 0,121,000 on this dial, with the pointers in the correct position. Now suppose we take Fig. 3 and move Nos. 2 and 3 pointers, from the left, ahead to the positions in Fig. 4; then we get the position of the pointers on Mr. Fredericks' dial. This shows two misplaced hands, and if we run the pointers back by actual count 0,091,000, all hands come to 0 except Nos. 2 and 3, as in Fig. 2, which are misplaced by the same amount as shown in Fig. 4. This condition therefore proves the solution to be 0,091,000.

Fig. 6 shows 0,121,000 as the reading with all pointers correct as in Fig. 1. Taking Fig. 6 and moving No. 3 pointer back to the position in Fig. 7, we again have the arrangement of Mr. Fredericks' dial and have misplaced only one hand to get it. If now this dial is run back by actual count, 0,121,000 all pointers come to 0 except No. 3, Fig. 5, which shows the same error as in Fig. 7. This series therefore proves my solution of 0,121,000 as the correct reading. These dials bring out interesting conditions of which I, and no doubt others also, have not before considered; namely, two perfect solutions of one problem. The two readings give a difference of 30 kw.-hr. Although this would amount to considerable where the regular monthly consumption is small and would be a fairly accurate guide as to just what the actual misplacement was, when the monthly consumption is large, 30 kw-hr. one way or the other is not sufficient difference to give a correct indication as to what the errors in the meter dials are



FIGS. 1 TO 7. ARRANGEMENT OF METER DIALS TO GIVE TWO DIFFERENT READINGS

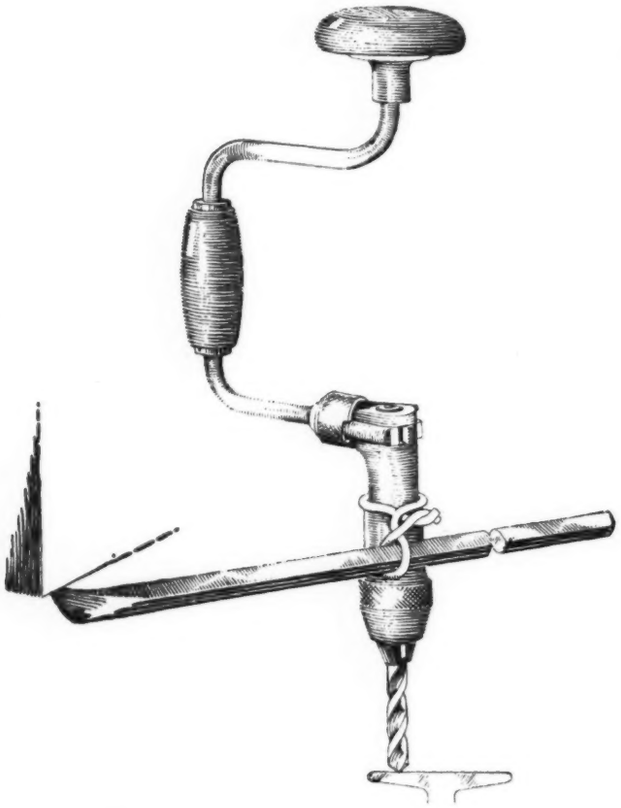
It would be interesting to hear from Mr. Fredericks as to what he found the correct reading to be.

Patchogue, N. Y. HARRY MULFORD.

Getting Pressure on a Bit Brace

A short time ago I had to drill a hole through a ¾-in. iron casting. I had but an ordinary bit brace and a bit-stock drill, and could not bring enough pressure to bear on the drill in the ordinary way, so I devised the following method:

In the first place I secured a piece of heavy iron wire and gave it a turn around the brace in such a



GETTING A PURCHASE ON A BIT BRACE

way that it would not interfere with its working. I then wound the wire around an iron bar and used it as a lever, as shown in the sketch.

With this simple contrivance the hole was easily and quickly drilled, my helper pulling down on the lever while I turned the drill. W. W. PARKER.

Firestone, Col.

Why Does the Water in a Boiler Lift When Safety Valve Blows?

A boiler under pressure and generating steam faster than the demand must find an outlet through the safety valve, the area of which is increased when once raised from its seat, and consequently, the valve opens wider than is necessary for that given pressure.

As the pressure in the boiler is increasing and pressing harder against the safety valve to open it, when blowing off, an instantaneous release of steam from the steam space of the boiler is the result. This sudden release of pressure creates a disturbance throughout the body of water in the boiler, the violence of which depends on existing conditions. If the valve opens wider than the pressure demands, the pressure falls back on the boiler. A drop in pressure causes all the water in the boiler to have a tendency to flash into steam, by reason of the so-called latent energy of heat. Particles of steam mingling with the water will rush toward this outlet of receding pressure, carrying water with them, the amount depending on the condition existing at the time. WILLIAM TOMPKINS.

Philadelphia, Pa.

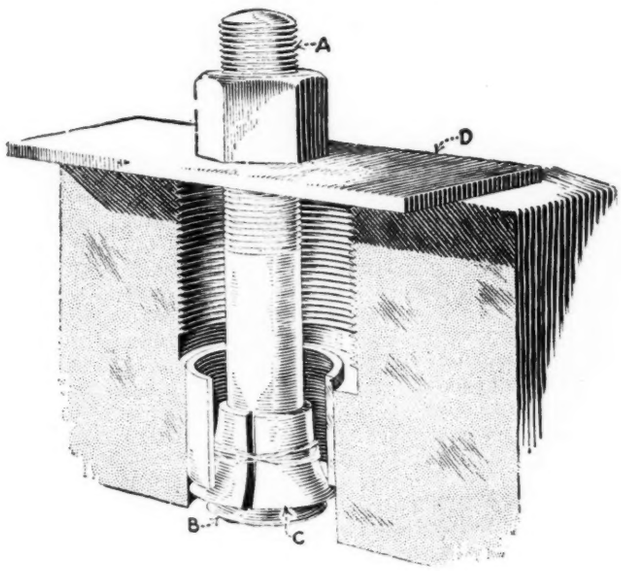
My opinion is that as the pressure is increased, the boiling point of the water also increases, and if this pressure is suddenly lowered the boiling point is also lowered. This would cause a relatively large amount of water to flash into steam, which causes the water to increase the violent motion that takes place under ordinary conditions. This motion, however, becomes so violent that the disengagement space in the boiler is not large enough to permit of the separation of the water and steam, consequently the result is that the water level rises.

If the pressure were suddenly reduced low enough, it would, without doubt, cause an explosion.

Van Buren, Me. WILLIAM B. SMITH.

Tool for Pulling Worn Hydraulic Valve Seats

For pulling out worn hydraulic-valve seats, the tool shown herewith is a time and labor saver. To make, turn down a piece of round stock long enough to be used on the pump, as shown at *A*, and threaded for a ⅞-in. nut, providing enough stock at the other end to turn a 30-deg. taper and of a diameter to make a sliding fit through the valve seat. Make a bushing *C* to fit



HOW THE VALVE-SEAT PULLER IS APPLIED

halfway down on the taper of the puller, the bottom end of the bushing having a slight lip. Then split the bushing with a hacksaw and the tool is made.

To use, push the puller through the valve seat and then put the bushing on the puller, holding it together with a rubber band. Next push the bushing down over the taper of the puller until a good hold is obtained on the valve seat; then put the iron clamp *D* over the puller and jack the seat out with the nut.

Trenton, N. J. JOHN F. LOCKETT.

Maximum Length of Longitudinal Joints for Boilers

Reverting to the discussion regarding the maximum length of longitudinal joints for steam boilers published in *Power* during the last six months, all of which is very interesting, it appears that the various writers have confined themselves principally to expressions of opinion from the constructional point of view only. In addition to this, there is much to be said from the operators', owners' and underwriters' standpoint.

The Massachusetts rules do not allow a boiler of the horizontal return-tubular, vertical-tubular or locomotive type to be constructed with longitudinal joints over 12 ft. in length. The A. S. M. E. Code prohibits a joint of the lap-seam type in a horizontal return-tubular boiler over 12 ft. in length, and with butt- and double-strap construction a joint of any length may be used in any type of boiler. Why does the A. S. M. E. Code limit the length of a lap joint in horizontal return-tubular boilers only?

From my viewpoint, fire-tube boilers, if constructed under either of the codes mentioned, which require a good quality of material and good workmanship, would be practically immune from explosion provided all the requirements are faithfully complied with and the boilers are operated under proper conditions.

It would appear that both of the codes referred to could be altered with safety to meet all conditions and I favor a rule leaving the length of the butt- and double-strapped joint optional on internally fired boilers, such as the vertical or locomotive types, or in the drums of water-tube boilers or other types of boilers where the shell plates are not in direct contact with the products of combustion.

I believe it would be unwise to change the Massachusetts rules so far as they apply to the maximum length of joints for horizontal return-tubular boilers, and if possible; in fact I would prefer that the length be limited to nine or ten feet for the following reasons:

Distress at the girth seams of horizontal-tubular boilers is first evident at the bottom of the course and directly over the fire, and leakage from this point is invariably an early indication of trouble, due to internal conditions.

A leaky girth seam has frequently been the cause of preventing extensive repairs, serious accident and possible explosion, and is a warning to the attendant in charge. It is usually a result of an accumulation of grease or scale on the fire sheets, which, but for this warning, may have resulted in further overheating of the material, causing serious bulges and other defects. For this reason I believe the girth seam has a strengthening effect on the plate and also that it is more effective when the plate is overheated, distorted and deteriorated.

In over thirty years' experience I have had occasions to examine and note the effect of overheating in a large number of horizontal-tubular boilers, all of which were constructed with two or more courses, and I am firmly of the opinion that in some instances serious explosions would have resulted if the boilers had been built with one continuous course and without the strengthening effect of the circumferential joint.

If the girth seam is eliminated and overheating occurs, the bulges would be of larger area, the depression greater and the possibility of serious rupture considerably increased. With a long sheet, bulging, due to overheating, is more likely to occur from lack of notice through leakage at the girth seam.

The rupture of tubes in water-tube boilers is due either to the quality of the material and gage, poor workmanship, or overheating, and without the strengthening effect of a roundabout joint they frequently open lengthwise a distance of six or seven feet, resulting often in loss of life or serious accident to persons as well as extensive damage to property. Similar accidents could happen in vessels of greater diameter than tubes, such as one-course boilers.

Frequently it becomes necessary to replace an entire course in a horizontal-tubular boiler when the plate has been badly distorted. This would be a very expensive operation if the boiler was built in one course, and might necessitate the construction of a new boiler.

I have had occasion to examine a large number of horizontal-tubular boilers, many of which have been operated for a number of years under rather severe conditions externally. Where the internal conditions and material are good and the girth seams properly constructed, trouble from leakage at the seams does not occur.

In my opinion neither the Massachusetts Rules nor the A. S. M. E. Code should permit the construction of horizontal return-tubular boilers with a longitudinal joint of greater length than twelve feet. To bring about uniformity, it would appear to be necessary to make changes in both the A. S. M. E. code and the Massachusetts rules.

J. FRANCIS.

Boston, Mass.

Anent the discussion regarding the maximum length of longitudinal joints, the A. S. M. E. Code specifies that in a horizontal return-tubular boiler with lap joints no course shall be over 12 ft. long. Provisions have been made for the use of courses of any length in a horizontal return-tubular boiler with longitudinal joint of the butt- and double-strap construction.

The Code is then very explicit on the length of course for one type of boiler and especially for one form of construction. The reason for demarcation so sharp is not readily apparent, for it would seem that if several short courses would give greater strength than one long course in lap-seam construction, the same would hold true with butt- and double-strap construction.

If, too, it is desirable that the direction of the longitudinal seam should bear a certain relation to the direction in which the tension-test specimen was taken in a long course for a horizontal return-tubular boiler, why is it not advisable to require a similar tension test in a continuous course for a drum boiler?

Regardless of the type of boiler, a limitation on the length of course would be desirable, and 12 ft. is none too short. If a study is made of the lap-seam failures and these are not confined to any one type of boiler, it will be found that almost invariably the ruptures started at or near the middle of the joints and tore toward the girth seams. Again, in the event of overheating of the sheets of an externally fired boiler, the plates will often be badly distorted both sides of the girth seam. Rarely will the seam be affected other than to show leakage, and the leakage is often the first inkling the attendant has that something is wrong with the boiler and that it should be shut down.

In laying out a boiler made in courses, it is almost universal practice to break joints; that is, the longitudinal joints are not in a continuous line. Advantage of the strengthening effect of the girth seams is taken in this way. If courses of unlimited length were permitted and a boiler should be built in one course, the stiffening effect of the girth seams would be lost.

South Boston, Mass. J. C. CRAFFEY.

Possible Causes of Boiler Explosions

In recent issues of *Power* there have been published accounts of two boiler explosions. In both cases the boilers had been cut out and the night crew was getting up steam to put them in service again when the explosion followed. In the last few years I have been roaming from one plant to another, and in that time have had many types of boilers under observance. Perhaps the following may add some information to what has already been published.

In one instance the safety-valve stem was found to be so corroded that the explosion was laid to that. The fireman was on top of the boiler prior to the explosion. What was he doing up there? Trying to loosen up the safety valve so that it would blow in order to release some of the excessive pressure? That is a conjecture that I do not place any stock in. Any fireman, irrespective of his mental caliber, knows whether his safety valve blows off at the required pressure. He does not work long before he makes sure of that one thing. The fireman in that plant knew as well as the investigation brought out that the safety valve was not working. Knowing this condition, he would not go up on top of the boiler to tinker with a safety valve.

I was working in a plant containing three return fire-tubular boilers carrying 105 lb. pressure, and the safety opened at that pressure. A few nights after taking charge, while I was talking with the night fireman in the boiler room, he asked if I knew what to do if the safety valve did not blow at the required pressure.

After explaining to him the safe course to take in a case like that, he proceeded to put me "wise" as he termed it, to the following: On top of the boiler and direct to the boiler shell there was connected a short 1-in. nipple and a 1-in. valve, and in case the safety valve did not open up at the required pressure, he went on top of the boiler, opened the 1-in. valve and allowed the boiler to relieve itself.

I told the fireman that if he was caught trying that stunt he would be thrown down from the top of the boiler. He was completely taken aback and replied that the former night engineer had told him that was the correct thing to do, and that was why that connection was placed there. Can it be possible that this was the reason that the fireman went on top of the boiler in the case of explosion under discussion?

The other boiler explosion was laid to a frozen safety valve. The author of the article covered the field very thoroughly. Still there were a few things that one may comment on. It is my experience that when the connection to a pressure gage is frozen, the pressure does not have a tendency to remain stationary, but the opposite. During the last cold spell, when the fireman was cleaning fires I heard the safety valve "pop." Shortly after I became aware that the engine was slowing down. At the same time the fireman called for me. Going to the boiler room I saw that the gage showed 125 lb. pressure instead of between 90 and 100 lb. which should have been carried. Looking into the furnace, I found that the fire was nearly out, which, of course, accounted for the slowing down.

In order to check up my suspicions, I went into the engine room and looked at the recording pressure gage, which showed that the steam pressure was down. Then there was no more doubt as to the trouble. After the ¾-in. line leading to the pressure gage was thawed, the pressure came down to normal.

The foregoing shows in a way that a recording pressure gage ought to be a part of the equipment of a power plant. If there had been one gage in the plant where this explosion occurred, the unfortunate incident might have been avoided, provided the instrument was used intelligently.

Another matter that those in charge of power plants might think over carefully: Nightwork and daywork are two different things. The man who works nights has a much harder time to get his rest than the one that works days. There are too many unknown conditions that enter in the problem when a man is trying to get his rest after working nights. There are times when it is impossible to get the right amount of rest, and it is not in human nature to be efficient during the long hours of the morning. Therefore why not have all the important work of a power plant done in the day under the watchful eye of the chief, leaving only the routine work for the night shift? Of course, this is not always possible, as there are times when everyone has to be on his toes, but this is only in exceptional cases.

It is a fact that work that could be done in the daytime is given over to a night shift in order that the men will have something to do besides their regular work. Take the matter of getting a boiler back in service. The night crew is told to get up steam on the boiler and have it ready to cut in service by the next morning. Nine times out ten that boiler is neglected until very near quitting time, and then it is forced in order to raise the steam pressure as quickly as possible. Is it any wonder that with the conditions right and forcing the boiler in that manner explosions occur? THOMAS GRAY.

Bayonne, N. J.

Licensing Steamfitters

After reading the correspondence on "Licensing Steamfitters," on page 394 of the March 9 issue, it appears to me that men who have come up in the ranks by the old method of learning through experience are a little too hard on the men who have technical training. All of us had to start getting experience at some time, and this includes both the man with and the man without training. I will venture to say that of two men, both being equally interested in their work in the beginning, the man with technical training will advance at a more rapid rate than the one without it.

I know a good many mechanics who cannot write, and these men are slow to follow the rapid strides in engineering, but as advancement is necessary to the welfare of all, let us bury the hatchet and give the man with training the same deal that the "old fellows" gave us who did not have training when we started.

St. Louis, Mo. F. KLUGMANN, JR.

INQUIRIES OF GENERAL INTEREST

Electrical Conductivity of Water—Is water a good or a poor conductor of electricity? A. J. C.

Chemically pure water is an insulator of electricity, but when water is contaminated with almost any other substance it becomes a conductor.

Separate Cold-Water Feed Connection for Boiler—What is the advantage of supplying a boiler with a separate cold-water feed line? R. St. T.

A separate cold-water feed line is desirable for filling the boiler after cleaning and for testing purposes, and also for regular feeding during such emergencies as when the feed-water heater lines are inoperative from corrosion or incrustation with scale, or during temporary disuse of the heater.

Angle of Advance of Eccentric—What is the angle of advance of the eccentric of an engine? B. R.

It is the angle that the eccentric is placed ahead of a line which is at right angle to the crank. Where the valve is moved by direct connections from the eccentric, the angle of advance is the number of degrees the eccentric is set more than 90 degrees ahead of the crank. Where a reversing rocker is used, the angle of advance becomes the number of degrees the eccentric is set less than 90 degrees behind the crank.

Blowdown of Safety Valve—What is meant by adjustment of the blowdown of a safety valve? W. G. M.

"Blowdown" is the less number of pounds pressure per square inch at which a safety valve closes than the pressure at which the valve is set to pop open. In most forms of spring pop safety valves, the amount of blowdown may be varied by adjusting the position of a ring, called the blowdown ring, which surrounds the valve seat and deflects the escaping steam in such a manner as to assist in holding the valve open until the boiler pressure has been reduced by the amount of blowdown.

Confining Operations to a Single Boiler—We must renew our boiler plant, consisting of two 75-hp. boilers. One of the old boilers is sufficient for our requirements during the summer months, but to supply our winter requirements for steam it is necessary to operate both boilers. Would there be better operating economy to replace the present 75-hp. boilers, or install one 150-hp. boiler for use the year around? T. B. C.

By skillful firing and reducing the grate area during the summer season, employment of a single 150-hp. boiler might effect a small saving of fuel, but with only one boiler there would be fewer opportunities for cleaning and making repairs without shuting down the plant.

Measuring Amount of Blowoff—What quantity of water will be discharged from a boiler under 160 lb. gage in blowing off to the atmosphere through a 2½-in. blowoff pipe that discharges to the atmosphere? H. L. S.

An accurate estimate of flow could not be based on simply the boiler pressure, as the rate of discharge would depend on the pressure obtained in the discharge end of the blow-off line after deducting the losses of pressure in the line. The best method of estimating the amount discharged would be to mark the water level of the boiler and, after blowing off the boiler with all other outlets closed, measure the amount of feed water required to restore the water level.

Equal Loads and Inequality of Cutoff—In a slide-valve engine, where the valve has equal laps at each end, will the leads and cutoffs be equal? R. C.

With equal laps there will be equal leads, but on account of the angularity of the connecting-rod, more angular rotation of the shaft and eccentric is accomplished when the piston traverses the crank-end half than when it traverses the head-end half of the stroke, and consequently the valve will be closed with cutoff accomplished earlier for the stroke from the crank end than from the head end. By moving the valve on its stem toward the head end, the cutoff of that end will be made earlier and cutoff in the crank end will be made later, but the lead of the head end will thereby be reduced and lead on the crank end increased.

Discharge of Attached Circulating Pump—What number of British gallons per minute would be handled by an attached double-acting circulating pump 15 in. in diameter by 21 in. stroke, with 2-in. piston rod, driven by a beam from the crosshead of an engine making 80 r.p.m., assuming that the pump barrel is filled 80 per cent at each stroke? C. E. G.

The 15-in. diameter piston would have an area of $15 \times 15 \times 0.7854 = 176.71$ sq.in., and with a 2-in. diameter piston rod the net area of the piston on the rod side would be $176.71 - (2 \times 2 \times 0.7854) = 173.57$ sq.in. For a 21-in. stroke, 80 per cent of the pump barrel filled at each stroke, and for 80 r.p.m. of the engine, the water displacement by the pump would amount to $(176.71 - 173.57)\ 21 \times 80$ per cent $\times\ 80 = 470{,}776.322$ cu.in. per min. As a British gallon is 277.274 cu.in. the quantity of water handled would be $470{,}776 \div 277.274 = 1{,}697.8$ British gallons per minute.

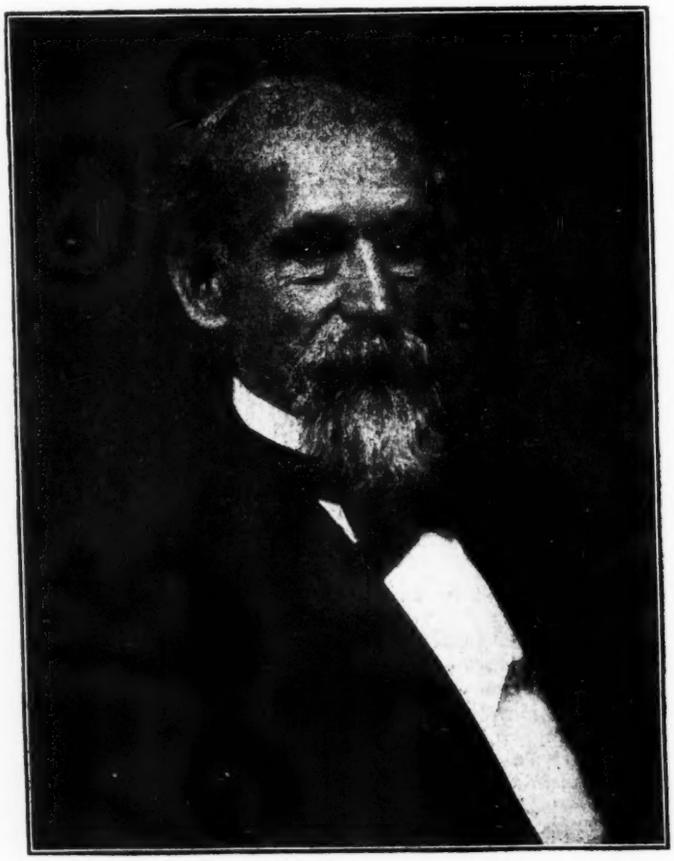
Inverted Converter—Can a rotary converter be used to tie an alternating-current system and a direct-current system together so that power may be transferred from one system to the other? C. M. B.

If the converter is shunt wound, it may be used for this purpose, but means must be provided to prevent the machine from racing in case it is supplying power to an alternating-current load of low lagging power factor. A wattless lagging current supplied from the collector rings of the converter will weaken the field pole and cause the machine to race unless it is operating in parallel with other alternating-current machines. Converters operated in this way usually have their field coils excited from a direct-current generator driven directly from the converter's armature shaft. Then, when the converter attempts to race, the voltage of the exciter is increased and that, in turn, increases the field current and neutralizes the demagnetizing effect of the wattless current supplied by the armature.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

Dr. John A. Brashear, Past President A.S.M.E., Dies

DR. JOHN A. BRASHEAR, past president of the American Society of Mechanical Engineers, died at his home in Pittsburgh on April 8, following a lingering illness. Dr. Brashear was an astronomer of world-wide reputation and his work in connection with the design and development of the spectroscope for astronomical uses, particularly with reference to accuracy of mechanical and optical features, will stand as his most notable achievement. His activities were not confined to the sciences alone. He was intensely interested in practical engineering affairs and for many years was an active member of the American Society of Mechanical Engineers, of which he was elected president in 1915. He was first elected to membership in the society in 1891, and in 1908 he was made an honorary member. From 1899 to 1902 he was one of the board of managers and in 1911 was one of the representatives on the John Fritz Medal Board, which post he held for four years. Dr. Brashear was born in Brownsville, Pa., in 1840, and received his education in the public schools of that town. From the public schools his desire for mechanical work led him to the rolling mills in Pittsburgh, where he worked as a machinist from the year 1860 to 1880. While employed in the mills he devoted his leisure hours to the study of astronomy, of which he was passionately fond. As a youngster it had been his ambition to study the mysteries of the heavens, and as he grew older his hunger for a knowledge of astronomy became stronger. He was too poor at this time to purchase a telescope, so he and his wife proceeded to make one. After a great deal of planning and work, a shop was finally set up in their home, containing a small steam engine, lathe and other apparatus necessary for the construction of the telescope. Here, after a great deal of laborious work, the tubes were made and the lenses for a five-inch telescope were ground. The instrument was three years in the making and was far from perfect, but it served its purpose and aroused the desire for a larger and better one. Work was immediately started on a twelve-inch telescope. Luck was against them, however, for after almost two years had been spent on grinding the lens, it broke. But, nothing daunted, the indomitable man and his wife began work on a new lens, which was successfully completed. The late Dr. E. C. Langley, former head of the Smithsonian Institution, then head of the Allegheny Observatory, noticed the young chap's enthusiasm for astronomical knowledge and placed him in a shop in Pittsburgh, where he was assisted by his wife. Finally, with the assistance of William Thaw, one of the observatory patrons, Dr. Brashear set up a small plant in Allegheny for the manufacture of astronomical instruments. Many of the spectroscopes used in the principal observatories of the world were turned out at this shop. In 1888 he completed the spectroscope for the thirty-six-inch telescope of the Lick Observatory, furnishing the optical and mechanical parts. When the international body on astronomical research was entrusted with the determination of a scientific standard of measurement fixed upon the length of a light wave as the most efficient means of securing uniformity, Dr. Brashear was selected from all the instrument makers in the world to do the important work of manufacturing the apparatus. The instruments were of a delicate and accurate nature, and it was believed that Dr. Brashear, with his wide experience, was the man best suited for the work. Following the opening of the shop at Allegheny, his son-in-law, James B. McDowell, joined him in the work and Dr. Brashear attributed a large share of the success of the enterprise to Mr. McDowell. In 1898 he received an oppointment in the University of Western Pennsylvania, of which the Allegheny Observatory was a department. For twenty years he was trustee of the Carnegie Institute, for fifteen years of the Carnegie Institute of Technology and for twenty years of the University of Pittsburgh, which he also served as Chancellor. Dr. Brashear's work in connection with the advancement of teachers and education in the public school has proved of inestimable value. An endowment fund of $250,000 was placed in his care by a friend several years ago to be used for the advancement of public-school teachers and teaching, as a result of which hundreds of teachers were sent to different parts of the country for rest and study, bringing back with them new ideas and greater enthusiasm for their work. He was honored by Washington and Jefferson College with the degree of LL.D. and by Princeton University and the Western University of Pennsylvania with the degree of Sc.D. He was a member of the American Association for the Advancement of Science and the Royal Astronomical Society of Great Britain; past president of the Engineers Society of Western Pennsylvania and the Pittsburgh Academy of Arts and Sciences; a member of the British Astronomical Association, the Societe Astronomique de France, the Societe de Belgique, the American Philosophical Society, the Astrophysical Society of America, the National Geographic Society, Washington Academy of Sciences and an honorary member of the Royal Astronomical Society of Canada.



DR. JOHN A. BRASHEAR

Refrigerating-Machinery Lubrication*

AT THIS season manufacturers of ice and operators of cold-storage plants are overhauling their machines and installing new equipment in anticipation of the demands of the hot weather which is approaching. Because of the plentiful supply of natural ice recently harvested in many parts of the country, makers of the artificial product will find competition very keen, and it is urgently necessary that they operate the plants at the highest possible state of efficiency. The surest way to obtain maximum production with minimum operating expense is to eliminate friction and leakage in the compressor cylinders and to provide against the fouling of the refrigerating coils with congealed oil.

The lubrication of refrigerating machinery is peculiar in that the choice of the oils to be used is influenced by the action of those oils upon parts of the apparatus not requiring lubrication. The lubrication of the apparatus employed in air refrigerating systems belongs under the head of air-compressor lubrication and will not be discussed here. The absorption process is chemical rather than mechanical, and the only parts of such apparatus requiring lubrication are the pumps, which, however, offer no unusual features. In the compression process the refrigerating agent is recovered by means of mechanical compression. A number of substances have been used as the heat-carrying medium, but anhydrous ammonia has been most widely adopted.

Ammonia is compressed in one of two ways—by the wet method or by the dry method. In the former a small amount of liquid ammonia is allowed to enter the compressor and, owing to its evaporation, serves to keep the temperature of compression down. In selecting an oil for wet-compression machines, it is necessary to choose one which will remain a fluid at the minimum temperature in the expansion side of the system, and of sufficiently high flash point to prevent distillation at the discharge temperature. However, as the discharge temperature is comparatively low, the cold or pour test and viscosity are the only important factors.

In the dry method vapor alone is drawn into the machine; that is, the ammonia gas entering the compressor will be slightly superheated. The majority of machines operating in this class of work are vertical, single-acting compressors with water jackets.

An oil for this class of work should have a sufficiently low pour test to remain a fluid at the minimum temperature in the evaporating side of the system, a flash point high enough to stand the discharge temperatures without distillation and enough viscosity to lubricate the compressor parts and seal the piston rings and compressor valves. As cylinder temperatures are considerably higher in dry compression than when the wet method is employed, it is desirable that an oil having a higher viscosity be used, and in addition the oil should have a flash point sufficiently high to prevent distillation or cracking at the discharge temperature. A good ammonia oil should have a flash point at least 25 deg. F. higher than the average discharge temperature.

Four Classes of Compressors

We may divide the different types of ammonia compressors into four general classes: Vertical single-acting compressors; horizontal double-acting compressors; inclosed high-speed compressors; rotary compressors.

Vertical single-acting compressors are built in various sizes from one-eighth ton capacity upward. The smaller types of these are usually lubricated by the splash system in a manner similar to that employed in automobile engines. When the back pressure drops below atmospheric in this type of machine, there is always danger of oil being drawn into the cylinder, but this will never occur if the attendant watches his gages closely and maintains the back pressure at the proper value. The ammonia piston used in a great many of these machines is of the double-trunk type, with the charge entering between the upper and lower sections. The upper section is fitted with two or three rings and also contains a valve. The lower section carries one or two rings which form a seal between the crank case and the suction of the machine. These serve to prevent excess oil from being drawn into the cylinder when the back pressure drops. A light oil gives very satisfactory results on this type of compressor.

In machines using the splash system it is important that the oil level in the crank case should not be kept too high. A high oil level causes excessive churning and is likely to lead to the introduction of oil into the refrigerating system. In the larger sizes of vertical machines the lubrication is accomplished through the use of a force feed.

Some double-acting compressors are lubricated by introducing the oil at the piston-rod stuffing-box, which is fitted with an oil lantern. The small amount of oil working into the cylinder past the packing is found to afford ample lubrication. When this method is employed, it is found that the oil protects the packing from the very injurious action of the hot ammonia gas.

Avoid Copper or Its Alloys

Other compressors are lubricated through the use of positive force-feed lubricators, but where these are used precautions should be taken to see that they are constructed entirely of iron or steel. No copper or copper alloys should be used about an ammonia compressor. These lubricators assure efficient lubrication, in that they put the right amount of oil in the right place at the right time, and do this at the minimum cost. Oil is sometimes introduced into the cylinder through the intake line, but this method is becoming obsolete.

The lubrication of the bearings of a compressor presents no unusual difficulties. When the splash method of lubrication is employed and one oil is used for both the cylinder and the bearings, an ammonia oil of some type must be used, but when the oil is not used in the cylinder any high-grade non-emulsifying oil may be employed. The same grade of oil may also be used when a circulating system is employed. When the oil is fed from cups or a force-feed lubricator, any high-grade engine oil will prove satisfactory, the viscosity, of course, being suitable for the weight and speed of the machine in question.

The selection and proper application of a suitable lubricating oil for the ammonia compressor is one of the duties of the lubricating engineer and a question of much importance to the engineer operating a refrigerating plant. In selecting an oil the character of friction, pressure, temperature and velocity and position of the moving parts, as well as the chemical nature and the composition of the lubricating oil, must all be considered. Some attention must also be devoted to the chemical properties and temperature of the materials with which the oil may come in contact.

It should be noted that only pure mineral oils of at least zero pour test should be used in the cylinders of an ammonia compressor. These oils can be obtained with a sufficient range of physical properties to lubricate satisfactorily and efficiently all such compressors working under reasonable conditions. Mineral oils are the most neutral, and a pure straight mineral oil well refined has been found to be the most suitable for this class of work. Compounded oils of any kind should be avoided because of the tendency of animal and vegetable oils to solidify at comparatively high temperatures. Acids which develop in compounded oils also attack the walls of the compressor cylinder and have a detrimental effect upon the ammonia gas.

In so far as the lubrication of the compressors themselves is concerned, viscosity is of primary importance. The condition of the cylinder, piston rings and valves determines the viscosity of the oil that should be used, as it is essential that the oil should form a seal and maintain perfect compression. For cylinders that are in good condition a light-bodied oil will prove satisfactory. Where the cylinders are somewhat worn or scored, a medium-bodied oil will usually maintain the required seal. In cases where the

*Abstract of an article published in *Lubrication* for March, 1920.

rings and cylinder are badly worn or scored, it may be necessary to use a heavy-bodied oil to insure efficient operation. Generally speaking, horizontal machines, owing to the position and weight of the piston, require an oil of heavier viscosity than the vertical type, and as most of the horizontal compressors are double-acting, the lubrication of the piston rod should be taken into consideration.

As was mentioned before, it is doubtful if the temperature of the oil in the compressor is ever raised much above 250 deg. F. As all high-quality oils have flash points well above 300 deg. F., it would seem that the question of flash point might safely be disregarded in selecting oils for compressor lubrication.

While oils having the characteristics just discussed will satisfactorily lubricate the compressor cylinder, requirements of other parts of the plant frequently make necessary the use of an oil having other physical characteristics. There will always be some vaporization of oil due to the heat of compression, no matter how high the flash point may be, and this vapor will be carried out of the cylinder with the compressed gas. As refrigerating systems are closed cycles, this oil is bound to condense and accumulate upon the colder parts of the system, which are the condenser and expansion coils.

Oil Accumulations on Coils Detrimental

Probably no other item in the operation of a refrigeration plant so vitally affects economy as the accumulation of oil upon the coils, and yet it is amazing how few operating engineers take this problem seriously. A prominent authority has asserted that a film of oil one one-hundredth of an inch thick has the same heat-resisting properties as a layer of boiler scale one-tenth of an inch thick and a steel plate ten inches thick. All oils, when sufficiently cooled, become thick and at certain temperatures cease to flow. Unless the oil reaching the condenser and refrigerating coil has an extremely low pour test, it is bound to accumulate on the walls of the coils and prevent the effective transfer of heat.

To prevent this condition, an oil used in a refrigeration compressor should have at least a zero pour test, so that any oil getting into the coils may be carried along with the ammonia without congealing upon the walls and seriously affecting the efficiency and capacity of the plant. Natural low-pour-test oils contain no paraffin wax, and consequently no trouble from this source will be experienced when they are used. Before the oils made from wax-bearing crudes are used on an ammonia compressor, it should be determined that the wax has been removed to such an extent that no evidence of its presence is seen after the oil has been exposed to the lowest temperature in the system. Any operator can make a test to determine the suitability of an oil for his particular work by immersing it in the brine for some time. If it flows readily upon removal, it is quite suitable; if not, it should be rejected.

Proper Location of Extractor

An essential appliance in any refrigeration plant is the oil extractor, of which there may be several. The principal extractor should be placed between the compressor and the condenser, although advantages will be secured by inserting smaller extractors at the lowest points of the condensing and refrigerating coils. Efficiency will always be promoted by the use of oil extractors, no matter how high the quality of the lubricant may be. Complaints are frequently made that the extractor does not function properly, and very often extractor troubles are charged to the oil being used. In nine cases out of ten, when the oil is not removed by the extractor, the difficulty is due to the extractor being placed too close to the compressor, at which point the gases are too hot to permit the oil to condense. When the extractor is located close to the condenser, the oil will reach it in a condensed form and as a result, can be more easily removed. Oil extractors should be of ample size so that the velocity of the gas through them shall not be too high to permit of complete separation.

The location of the oil extractor between the compressor and condenser and the efficiency of its operation have an important bearing upon the character of the oil selected. If conditions make it necessary to place the extractor near the compressor, an oil giving little evaporation—that is, a high-viscosity oil—should be used. On the other hand, owing to the opportunity which the vapor has to condense, a lower-viscosity oil may be used successfully when the extractor is placed some distance from the compressor. Provision should always be made to draw oil from the bottom of the liquid receiver in which it frequently accumulates in considerable quantities. As the oil has a higher specific gravity than liquid ammonia, it naturally settles to the bottom of the receiver from whence it may be drawn and passed through purifying devices.

Oil taken from the extractors and receiver may be recovered by installing an ammonia-distilling apparatus, which has the dual advantage of purifying the charge of ammonia and of recovering the lubricating oil without interfering with the continuous operation of the plant. The operation of these ammonia stills is so simple and well known to engineers in refrigerating work that it will not be necessary to go into details. Care should be taken in handling the still to prevent too rapid evaporation, as this causes boiling over and the loss of a large proportion of oil back to the suction line. After all the liquid ammonia has been evaporated and returned to the suction line of the compressors, the oil can be drawn from the bottom of the still, using suction pressure for the purpose. The oil removed will contain some water vapor and should be put aside until this has freed itself from the oil. Maintaining the oil at about 150 deg. F. will assist this operation materially. The oil is then ready to be filtered.

It is advisable to use a separate filter for this work, the size and type of filter to be used depending upon the size of the plant and the amount of oil to be handled. The oil recovered from the still, after careful filtering, will again be suitable for the lubrication of the ammonia compressors provided the original oil used on the compressors is of good quality and properly selected.

Filtering Oil Through Water

Some engineers are opposed to filtering compressor oils through water because of the danger of moisture retained by the oil being introduced into the cylinder upon the re-use of the oil. On the other hand, a great many engineers have never experienced any difficulty through water getting into the system with oil. In any case this difficulty may easily be circumvented by allowing the oil to stand a day or so before again placing it in the lubricating system. In a large number of plants the oil recovered is used for external lubrication only and new oil used for the lubrication of the ammonia compressors. This is safe practice, as there is then positive assurance that the oil used on the ammonia compressors is perfectly clean and up to specifications.

A record should always be kept of the quantity of oil taken from the extractor, and this should be compared at regular intervals with the amount of oil fed to the compressor. Any great difference should be investigated at once. The film of lubricating oil can always be removed from the condenser coils by discontinuing the cooling water from one strand at a time. When the pipes become hot, the oil will thin down and run off into the receiver. When the refrigerating coils become fouled with congealed oil, the accumulation may be removed by reversing the system and forcing hot gas through the coils. The same result may also be obtained by blowing out the coils with steam, followed by air to remove the moisture.

Temperatures play an important part in the efficient operation of any refrigerating plant, and to get the highest efficiency it is necessary to know what the temperatures are in the different parts of the system. This is also the most important consideration in selecting a lubricating oil for this class of work. Where thermometers are installed in both the suction and discharge sides of ammonia compressors, the selection of a lubricating oil becomes a very simple matter.

The ideal refrigeration oil should remain a fluid at the minimum temperature in the evaporating side of the system and not undergo any chemical change at the maximum temperature of the conpressor discharge. It should also

have sufficient viscosity at the working temperature of the compressor parts to lubricate properly and to form a seal for the piston rings and valves.

The importance of a suitable and efficient lubricant for the ammonia compressor in many instances is overlooked and an oil "just as good," selling for a few cents per gallon less, is installed in the plant. When we consider that the average 100-ton modern ice plant will not use more than fifty or sixty gallons of ammonia oil per season, the difference in price between the best grade procurable for this purpose and the cheapest oil sold, would not pay one per cent on the difference in cost of repairs, to say nothing of the possibility of a loss in capacity due to the excessive wear of the compressor parts. Better lubrication will have a very large influence on operating costs.

Revision of National Electrical Code

On March 23, in New York City, the Electrical Committee of the National Fire Protective Association held a public hearing on the recommended changes in the National Electrical Code as published in a bulletin issued some time ago. After the public hearing the electrical committee held a closed meeting at which the recommended changes as published in the bulletin were adopted with some few exceptions.

The limit of low potential systems was fixed at 600 volts instead of 750 volts as recommended in various sections of the bulletin discussed at the meeting. The proposal to require polarity identification in all wires installed on and after Jan. 1, 1921, was modified to require that beginning July 1, 1921, twin wires for conduit work and twisted-pair wires for armored cable, in sizes Nos. 12 and 14 B. & S. gage, provide a means for continuous identification as proposed in the bulletin for Rule 26a. Rule 77 on fixtures is to be revised to require identification marking by the fixture manufacturers of the wire connected to the screw shells of the socket.

A committee is to be appointed to consider requirements for the installation of concealed extensions from existing wiring in buildings of fire-resistive construction.

The report on rubber-covered wire was adopted essentially as printed. In this report a greater thickness of rubber insulation is required on 1,500-, 2,500- and 3,500-volt cables. A standard for the stranding of wires in building up stranded conductors for wires and cables is given. Allowable carrying capacities of the conductor sizes secured under this program are to appear as a new section of Rule 18. The general use of varnished cloth cables was approved for sizes of No. 6 B. & S. gage and larger.

The generator and substation report was adopted as printed. In addition the committee was asked to consider amendments to Rule 12 to exclude from its application, equipment of public utilities. The frames of generators are now required to be grounded when operating at a potential in excess of 750 volts, except where this is impractical or where operating conditions require their insulation. The grounding of generator and motor frames operating on 150 volts or less and accessible to only qualified operators is not to be required. Rule 7 has been changed to read: "Each distribution system originating in a station under attendance must be provided with a reliable ground detector unless permanently grounded as provided in Rule 15-A."

The report on the overload protection of motors was referred back with power to the Committee on Overload Protection for conference with industries and those interested. One of the recommendations contained in the report was, "Except on main switchboard or when otherwise subject to competent supervision, an approved fuse must be provided in each conductor of motor circuits whether an automatic circuit-breaker is installed or not. Circuit-breakers may be approved for circuits having a maximum capacity greater than that for which approved inclosed fuses are rated."

Recommendations for size and protection of conductors for motor circuits were also referred back to the committee with power and instructions to continue the last paragraph of present Rule 8c. Recommendations under the heading of motor switches were approved, but the report was referred back to the committee with power for rewording after considering the problem of large switches. The recommendation to require the externally operated inclosed type of switch for motor circuits was not adopted.

The report recommending not to require special permission for 1,320 watts on circuits with medium base sockets was not adopted, nor was the recommendation to change 1,320 to 1,500 watts. Provisions were made for the use of circuits up to 4,000 watts when Mogul sockets are used, but special permission will be required.

Spring Meeting of the A. S. M. E.

The American Society of Mechanical Engineers will hold its spring meeting in St. Louis, May 24 to 27, with headquarters at the Hotel Statler. A group of papers of general interest to the profession has been arranged by the committee on meetings and program.

Many features for the entertainment of members are being planned. This city is unsurpassed for its places of amusement. Special entertainment features have been arranged for the ladies by the Ladies' Committee, including an automobile trip to Forest Park and a visit to the Art Museum in the park. A trip through the residential and shopping districts will also be made.

The meeting will open at the Hotel Statler on the afternoon of Monday, May 24. Registration will be made at this time and council and committee meetings will be held. In the evening at a reception the governor of Missouri and the mayor of St. Louis will deliver addresses of welcome.

At the Tuesday morning session the business meeting will be followed by the rendition of papers of local interest on Mississippi River transportation and on housing problems, and in the afternoon there will be excursions to the plants of a number of industrial projects. The evening will be made jolly by a banquet and addresses. Lantern slides and moving pictures of the German fortifications on the coast of Belgium and of the transcontinental trip made in this country by Army motor lorries will be shown on this occasion or at some other time to be determined.

Wednesday will be the busiest day of the entire meeting. The morning will be taken up with simultaneous sessions on aëronautics and foundry practice, with papers on the following subjects: Aëronautic Session—"Air Flow Past an Airplane Wing," "Use of Turbo-Compressors for Increasing Power of Airplanes at High Altitudes," "Airplane Instruments," "Experiments on New Type of Airplane." Foundry Session—"Malleable Castings," "Die Castings," "Gray-Iron Castings," "Aluminum Castings," "Steel Castings," "Brass and Bronze Castings."

The afternoon session will be devoted to discussion on "Appraisal and Valuation" and excursions to various industrial plants, including the Busch-Sulzer Diesel Engine Co., the Mississippi Valley Iron Co. and the new Bevo plant. A special entertainment at the municipal open-air theater at Forest Park has been arranged for the evening.

Thursday, the closing day of the meeting, will begin with the presentation of papers on "Weir for Gaging the Flow of Water in Open Channels," "Simplification of Venturi-Meter Calculations," "Flow of Air," "Dissipation of Heat by Various Surfaces," "Pulverized Coal at the Cerro de Pasco Copper Corporation," "Method of Separation of Dissolved Gases From Water and Some of Its Uses," "Flow of Air Through Small Brass Tubes."

A boat trip on the river is scheduled for the afternoon, with a landing at the Chain of Rocks, where the filtering basin and pumping plant of the city will be inspected.

Inquiries have led us to infer that the title of the leading article in the April 6 issue: "Gas-Steam Unit Shows 72.4 Per Cent Thermal Efficiency at Ford Works," may be construed to apply to the engine cylinders only. However, as is explained in the article and synopsis, the 72.4 per cent includes the heat recovered from the jackets and the exhaust and represents that made available for power and heating purposes.

Personals

L. E. Gebhard, formerly connected with the Philadelphia sales office of the Yarnall-Waring Co., has been placed in charge of the Pittsburgh office.

Russel P. Askue, formerly connected with the publicity department of the National Lamp Works, has resigned to go into agency work, with headquarters in Cleveland, Ohio.

C. Thayer, formerly of Raleigh, N. C., superintendent of the Carolina Light and Power Co. in Oxford, has been transferred to Henderson as superintendent of the company's interests there.

Albert R. Dismukes, formerly with the Emerson Company, New York, has become affiliated with Joseph E. Lower, Inc., constructing engineers, Dayton, Ohio, in the capacity of efficiency engineer.

Colonel James B. Dillard, formerly chief of the Engineering Division of the Ordnance Department, has resigned his commission to become a member of the executive staff of the Cleveland Twist Drill Co., Cleveland, Ohio.

G. L. Behamon has resigned as chief engineer and assistant general manager of the Youngstown Steel Car Co., Youngstown, Ohio, and is now affiliated with the Thomas Spacing Machine Co., Pittsburgh, Pa., as manager of its Eastern office in Philadelphia, Pa

Edward C. Gaines, formerly engineer of the crane and conveying machinery department Dominion Bridge Co., Montreal, Canada, has joined the engineering forces of the Mead-Morrison Manufacturing Co., Chicago, Ill.

Samuel P. Hall, architect, and Harold M. Bush, mechanical engineer, announce they have formed a partnership under the name of Hall and Bush. The new firm will practice architecture and engineering as specialists and consultants in industrial-plant operation and construction.

Charles T. Main, of Boston, Mass., announces that his organization has been enlarged to undertake engineering work for all kinds of industries. Colonel F. M. Gunby who resigned to head the engineering branch of the constructing division of the United States Army, has returned and has been appointed engineering manager.

Professor Albert W. Smith, Dean of Sibley College of Mechanical Engineering, was appointed temporary successor to President Jacob Gould Schurman, who has retired, by the trustees of Cornell University on April 3. Professor Smith has been connected with Cornell University since 1887, at which time he was appointed assistant professor of mechanical engineering. In 1904 he was made a Director in Sibley College and in 1907 professor of power engineering. He is an active member of the American Society of Mechanical Engineers.

Society Affairs

The National Electric Light Association will be strongly represented at the annual convention of the United States Chamber of Commerce at Atlantic City, April 27 to 29.

The Cleveland Section of the American Society of Mechanical Engineers will meet at the Hotel Statler, Cleveland, in the Cleveland Engineering Society Rooms on April 27.

The National Association of Stationary Engineers will hold its twenty-fifth annual New York State Convention at the Temperance House, Niagara Falls, N. Y., June 10-12, 1920.

The Mid-Continent Section of the A. S. M. E. will meet April 29 at the Chamber of Commerce, Tulsa, Okla. A joint meeting with the Oklahoma Section of the American Chemical Society is being planned.

The Illuminating Engineering Society, Engineers' Club of Philadelphia, will hold a meeting on April 20, at Witherspoon Hall. The subject of the meeting will be "Labrador to Alaska" by L. O. Armstrong.

The St. Louis Section, American Society of Mechanical Engineers, will meet at the Hotel Statler in Cleveland on April 30. H. P. Gaum, engineer of the Illinois Stoker Company, will present a paper on "Chain-Grate Stokers."

The Society of Municipal Engineers, affiliated with the Engineers' Club of Philadelphia will meet at Witherspoon Hall, April 28. An illustrated lecture on "Health in Relation to Water Supply" will be given by John A. Vogleson.

The Cleveland Engineering Society, Cleveland, Ohio, will meet on Friday evening, April 30. Dr. I. N. Hollis, president Worcester Polytechnic Institute, will be the speaker. Subject: "Does Applied Science Add to the Satisfaction of Life?"

The Philadelphia Section of the Association of Iron and Steel Electrical Engineers will meet at its headquarters, Philadelphia on May 1. The meeting will be open for general discussion on the application of electricity to the iron and steel industry.

The American Association of Engineers has been appointed the official representative of railroad engineers under the Transportation Act, 1920. The association has a membership of 4,250 railroad engineers and will take up problems of railroad management.

The National Safety Council, Engineering Section will hold a meeting on April 27, in the Engineering Societies Building, New York City. Papers on "The Relation of Safety to Engineering Efficiency," "Safety Education in Engineering Colleges" and "Safety Standards" will be read.

The Birmingham Section of the A. S. M. E. will hold a joint meeting with the Atlanta Section on April 23, in Birmingham, Ala., at the Business Mens' Club at 6:30 p.m. John R. Allen, vice president of the A. S. M. E, will speak on "Theory and Practice."

The Southwestern Electrical and Gas Association will hold its annual convention in Galveston, Texas, May 15. The action of the electrical section of the association on the question of joining the Southwestern Geographic Division of the National Electric Light Association will come up at that time.

The National Electric Light Association national headquarters will be represented by A. Hardgrave, chairman of the Power and Light section of the Southwestern Electrical and Gas Association at the meeting of the Arkansas Public Utility Association, April 26. Mr. Hardgrave will outline the reorganization plan of the N. E. L. A.

The American Society of Safety Engineers will hold its next regular meeting at headquarters, Engineering Societies Building, New York City, April 23, at 8 p.m. Subjects: "Ladders and Scaffolds in General Building Construction"; "Safety As Applied to Ship Staging"; "The Requirements of the Industrial Code Relating to Ladders and Scaffolds."

The Pittsburgh Chapter of the American Association of Engineers recently expelled one of its members because of his connections with the draftsmen's union. The attitude of the Pittsburgh Chapter was that its members could not uphold the ideas of trade unionism and at the same time live up to the ideals of the association, which believes in co-operation between labor and employer.

The Society of Automotive Engineers, Engineers' Club, Philadelphia, will hold a special meeting at Witherspoon Hall on April 22. The society will hold a smoker at the clubhouse, Witherspoon Hall, on April 26. An illustrated lecture entitled "Eliminating the Slums," will be given by Emile G. Perrot. On April 27 a luncheon will be held, and an address by W. D. Lockwood on "The New Army."

The Engineering Section, National Safety Council, will hold its first spring meeting in the Engineering Societies Building, New York City on April 27. The entire program will be taken up with problems of engineering safety and the engineer's status in the industrial world. L. A. De Blois, manager of the safety section, E. I. du Pont de Nemours & Co., Wilmington, Del., will read a paper on "The Relation of Safety to Engineering Efficiency." A paper on "Safety Instruction in Engineering Colleges" will be presented by Bruce W. Benedict, manager of shop laboratories, University of Illinois. Other subjects will be: "How to Interest Student Engineers in Safety," Prof. G. S. Blessing, Swarthmore College, Swarthmore, Pa.; "The Movement for Uniform Safety Standards and the Engineering Sections Part," David S. Beyer, engineer, Boston, Mass.

Miscellaneous News

The Narragansett Electric Light Company, Providence, R. I., is considering the erection of an addition to the South Street Power house and the installation of eight new boilers. Total cost $750,000.

The Scottsville Power Corp., Scottsville, Pa. is completing arrangements for the development of the upper James River. Several thousand horsepower will be generated and distributed to towns in Pennsylvania and Virginia.

The Central Georgia Power Co., of Macon, has applied to the state railroad commission for an approximate increase of 28 per cent in power rates. The company supplies power for the operation of industries through middle Georgia.

The Columbus, Delaware and Marion Electric Company is planning the construction of a large power plant at Newmans, Ohio. The plant is to cost approximately $1,000,000. The contemplated improvements are to be made in two years.

The Municipal Power System of Los Angeles, Cal., will be increased to produce 300,000,000 kw.-hr. of electric energy per annum according to a recent announcement of the Public Service Commission. The present output of the system is 170,000,000 kw.-hr. and will be increased by the erection of another plant.

The Carolina-Tennessee Power Company is planning hydro-electric development on the Hiawassee River, power thus gained to be distributed for lighting and power purposes in North Carolina and Tennessee. It is estimated that 60,000 horsepower will be obtainable. The project will cost in the neighborhood of $10,000,000. Two 150-ft. dams are to be built. One is near the Tennessee border while the other is located thirteen miles up the river in North Carolina.

The San Joaquin Light and Power Corp., of Fresno, California has completed plans for the construction of a natural gas burning steam-generating electric plant. The plant will be built in units at a total cost of $6,000,000. The first unit will have a capacity of 17,500 horsepower, part of which will be transmitted to nearby oil companies. This will be the second steam plant erected by the San Joaquin Light and Power Corp. in Kern County during the past year.

Business Items

The Fisher Governor Company, Inc., Marshalltown, Iowa, manufacturer of power-plant specialties, announces the removal of its New York office to 242 Lafayette Street.

The Westinghouse Electric and Manufacturing Co. has been awarded the contract for the installation of an automatic electric substation on the line of the Seattle-Everett Interurban Co., Seattle, Wash. Total cost, $50,000.

The Pittsburgh Engineering Co. will move its general offices to Jeanette, Pa. The company will occupy the plant of the Greensburg Foundry and Machine Co. at Jeannette. Branch offices will be maintained as in the past.

The Cumberland Railway and Power Co., operating electric and street-car systems in North Carolina and West Virginia, will move its general offices from Norfolk, Va., to Raleigh as soon as the new Dortch Building, now being erected, is completed.

The Puget Sound Traction, Light and Power Co., Seattle, Wash., has changed its name to the Puget Sound Power and Light Co. Since the sale of the Seattle Street railway lines, the company has been concentrating on power and light business, hence the change of name.

The Schenectady Illuminating Co. and the Adirondack Power Corp., Schenectady, N. Y., are planning a merger for the purpose of acquiring the Brady lighting and power interests in several parts of the state, including the Glens Falls Gas and Electric Light Co. and the United Gas, Electric Light and Power Co., at Hudson Falls.

COAL PRICES

Prices of steam coals both anthracite and bituminous, f.o.b. mines, unless otherwise stated, are as follows:

ALANTIC SEABOARD

Anthracite—Coals supplying New York, Philadelphia and Boston:

	Mine
Pea	5.30
Buckwheat	$3.40@$3.75
Rice	2.75@ 3.25
Barley	2.25@ 2.50
Boiler	2.50

Bituminous—Steam sizes supplying New York, Philadelphia and Boston:

Latrobe	$4.25@$4.50
Connellsville coal	4.25@ 4.50
Cambrias and Sunset	4.25@ 4.85
Clearfields	3.75@ 4.50
Pocahontas	6.50@ 7.00
New River	6.50@ 7.00

BUFFALO

Bituminous—Prices f.o.b. Buffalo:

Pittsburgh slack	$6.25@$6.50
Mine-run	6.25
Lump	6.25@ 6.50
Youghiogheny	6.25

CLEVELAND

Bituminous—Prices f.o.b. mines:

No. 6 slack	$3.25@$4.00
No. 8 slack	3.50@ 4.00
No. 8—¾-in.	3.50@ 4.00
No. 6 mine run	3.50@ 4.00
No. 8 mine run	3.25@ 4.00
Pocahontas—Mine-run	3.25@ 4.00

ST. LOUIS

Anthracite—Probably not more than 20 per cent of the demand in this market can be supplied. Prices effective Apr. 1 were as follows:

	Williamson and Franklin Counties	Mt. Olive and Staunton	Standard
Mine-run	2.65@2.80	2.65@3 00	2.65@2.80
Screenings	2.50@2.65	2.50@2.65	2.50

Williamson-Franklin rate to St. Louis is $1.10; Other rates 95c.

CHICAGO

Bituminous—Prices f.o.b. mines:

		Freight rate Chicago
Illinois		
Southern Illinois		
Franklin, Saline and Williamson Counties		
Mine-Run	$3.00@$3.10	$1.55
Screenings	2.60@ 2.75	1.55
Central Illinois		
Springfield District		
Mine-Run	$2.75@$3.00	$1.32
Screenings	2.50@ 2.60	1.32
Northern Illinois		
Mine-Run	$3.50@$3.75	$1.24
Screenings	3.00@ 3.25	1.24
Indiana		
Clinton and Linton		
Fourth Vein		
Mine-Run	$2.75@$2.90	$1.27
Screenings	2.50@ 2.65	1.27
Knox County Field		
Fifth Vein		
Mine-Run	$2.75@$2.90	$1.37
Screenings	2.50@ 2.60	1.37
Brazil Block	$4 25@$4.50	$1.27

New Construction

PROPOSED WORK

Mass., New Bedford—Mowll & Rand, Archts., 50 Bromfield St., Boston, will soon award the contract for the construction of a 2 story, 143 x 160 ft. theatre and office building on Purchase St., for Gordan & Schoolman, 18 Tremont St., Boston. A steam heating system will be installed in same. Total estimated cost, $500,000.

Mass., Newton—(Boston P. O.)—The city will soon award the contract for the construction of a 4 story school building on Beacon St. A steam heating system will be installed in same. Total estimated cost, $500,000. W. G. Perry and J. H. McNaughton, 19 Congress St., Boston, Archts.

Conn., New London—The United States Electric Co., 108 State St., plans to build a power house.

Conn., Watertown—Louis A. Walsh, Archt., 51 Leavenworth St., will soon receive bids for the construction of a 5 story, 60 x 132 ft hospital on Franklin St., for St. Mary's Hospital. A steam heating system will be installed in same. Total estimated cost, $500,000.

N. Y., Malone—The Kirk Maher Co., 59 West Main St., is in the market for ice cream manufacturing mchy. to have a daily capacity of 7,500 gal., and 55 tons refrigeration equipment. Address Clarence E. Kilburn.

N. Y., New York—The Bd. Educ., 500 Park Ave., will soon award the contract for the construction of a school building at Crotona Park East A steam heating system will be installed in same. Total estimated cost, $900,000. C. B. J. Snyder, Municipal Bldg., Archt and Engr.

N. Y., New York—Deutsch & Poles, Archts. and Engrs., 50 Church St., will receive bids until April 23 for the construction of a 16 story office building at 7-11 Water St., for the Natl Park Real Estate Corp., 32 Union Square. A steam heating system will be installed in same.

N. Y., Olean—The taxpayers voted $200,000 bonds to build a heating plant for the high school and to improve the heating systems in other schools.

N. Y., Rome—The Rome Water & Sewer Bd. has had plans prepared by C. W. Knight, Engr., 101 West Liberty St., for the construction of a 350 hp. hydro-electric plant at Ridge Mills on the Montawk River. Estimated cost, $65,000.

N. Y., Sardinia—The Holland Sardinia Light & Power Corp. plans to construct a hydro-electric power plant including powerhouse, dam, etc., on Sardinia Creek, here. The powerhouse will be equipped with one 120 kva water wheel generator, one 96 kw. engine type generator, engine speed 276 r.p.m., one 7 kw. 125 volt compound belt driven exciter, one 150 kva. engine type generator, one 120 kva. engine type generator, engine speed 277 r.p.m., one 200 hp. type "Y" special Fairbanks-Morse engine, liquid fuel consumption and general equipment. Total estimated cost, $75,000. Manford L. Harrington, Pres.

N. Y., Theresa—The Orleans Four Corners Dairymen's League Co-operative Association, Inc., is in the market for milk handling machinery, refrigeration system and milk testing laboratory equipment.

N. Y., Whitney Point—L. J. White is in the market for a 40 hp. boiler.

N. J., Hoboken—The Bd. of Educ., Park Ave., will soon award the contract for the construction of a 4 story school building on Ninth St., between Garden St. and Park Ave. A steam heating system will be installed in same. Total estimated cost, $200,000. Charles F. Dieffenbach, Archt.

N. J., Trenton—J. R. Fell, Engr., City Hall, is in the market for a blower to eliminate the smoke nuisance at the city pumping station along the Delaware River. Estimated cost, $10,000.

Md., Baltimore—The Federal Motor & Sales Co., 803 Low St., will soon award the contract for the construction of a 3 story, 106 x 117 ft. garage, service and sales station on North Ave. and Lord St. (Grasshopper Hill). H. A. Loane, Builders Exch. Bldg., Archt.

Md., Baltimore—The Standard Oil Co., Pratt and South Sts., is having plans prepared by C. L. Reader, Consult. Engr., Park Ave. and Saratoga St., for the installation of a heating and ventilating system, etc., in the proposed 6 story, 90 x 140 ft. office building on Courtland and Franklin Sts. Total estimated cost, $500,000.

Md., Baltimore—Samuel T. Williams, 223 North Calvert St., is in the market for a 25 to 30 hp. upright boiler with or without stack (used).

Ga., Augusta—J. E. Sirrine, Engr., Greenville, S. C., will soon receive bids for the construction of a cotton mill, revamping water power plant and dye house, and electrifying all the machinery for the Sibley Mfg. Co., Goodrich St.

Tenn., Cleveland—The city is in the market for a pumping unit to have a 500 gal. per min. capacity and an electric motor for power.

Tenn., Knoxville—The John G. Duncan Co., Northeast Corner of Central and Jackson Sts., is in the market for second hand equipment, including one 3 hp., single phase, 60 cycle, 1800 r.p.m. motor and one 3 phase, 60 cycle, 1800 r.p.m. motor.

O., Cincinnati—The United States Engineer's Office, War Dept., Wash., D. C., is in the market for power house equipment to be used in connection with Dam 35 in the Ohio River.

O., Cleveland—The Cleveland Ry. Co., Leader News Bldg., is having plans prepared for the construction of three 1 story, 46 x 60 ft electric sub-stations at West 73d. St. and St. Clair Ave., East 80th St., and St. Clair Ave., East 152d St and St. Clair Ave. Two 1500 kw. rotary converters with blowers and generator sets will be installed in each. Total estimated cost, $300,000. L. P. Crecelius, 650 Leader-News Bldg., Archt. and Engr.

Ind., Lebanon—The Co. Comrs. plan to build a 2 story, 70 x 120 ft. jail and lighting plant. Two 60 hp. horizontal boilers, automatic stokers, pumps and radial brick stack will be installed in same. Total estimated cost, $100,000. John Frost, Lebanon, and Layton Allen, 406 Lombard Bldg., Indianapolis, Archts. Ammerman & McCall, 425 Occidental Bldg., Indianapolis, Engrs.

Mich., Milwaukee—The Michigan Light & Consumers Power Co., Jackson, plans to build a 2 story power station along the Saginaw River, here. Plans include a 30,000 kw. steam generating station. Steam boilers and engines to operate electric generating equipment will be installed in same. Total estimated cost, $4,893,000.

Ill., Chicago—The Bd. of Educ., 7 South Dearborn St., received bids for installing a steam heating system in the proposed 3 story, 132 x 175 ft. grade school on Augusta St., near Laramie Ave., from the Natl. Steam Heating Co., 1331 North Clark St., $39,423; William A. Pope, 26 North Jefferson St., $41,790; Kohlbry Howlett Co., 111 West Washington St., $43,043. Noted Jan. 27.

Minn., Red Lake Falls—Joseph Perrault, City Clk., will receive bids until April 26 for furnishing one 6 x 8 single acting triplex plunger pump of 175 gal per min. capacity against 150 lb. pressure or 350 ft. elevation.

Mo., St. Louis—Cornwell, Higgs & Gray, La Salle Bldg., are having plans prepared for the construction of a theatre and office building on Locust Ave. A steam heating system will be installed in same. Total estimated cost, $500,000 De Rosa & Pereira, 110 West 40th St., New York City., Archts. and Engrs.

Mo., St. Louis—C. G. and F. A. Hugh, 10th and Walnut Sts., are in the market for two 530 hp. type F., Sterling boilers, to have not less than 165 lb. pressure.

Tex., Bay City—The Texas Pub. Serve. Comm. plans to build an ice plant. Two large boilers, electric generator and machinery for a 15-ton ice plant will be installed in same. Total estimated cost, $60,000.

Tex., Clarendon—The Donley Co. Comrs. will soon award the contract for furnishing equipment and installing furnace and radiation for steam heating system at the county court house. Estimated cost, $10,000. W. T. Link, Co. Judge.

Tex., Clarkville—The city plans to install an oil engine to take the place of the steam plant now used as motive power for pumps at city waterworks.

Tex., Columbus—The Columbus Electric Light & Power Co. plans to renew its poles on all lines here, install additional generators, extend a transmission line from here to Glidden and furnish current for lights and power there.

Tex., Perrytown (Rogerstown P. O.) The Public Utilities Co. plans to install an electric light plant here.

Tex., Texas City—The Vacuum Oil Co., Foster Bldg., Houston, will soon award the contract for the construction of three 1 story buildings including 40 x 64 ft. and

40 x 50 ft. engine houses and a 40 x 56 ft. pipe house. Total estimated cost, $30,000.

Cal., Bakersfield—The School Bd. engaged C. H. Biggar and T. B. Wiseman, Archts., Morgan Bldg., to prepare plans for the construction of additions to 4 schools, etc. Steam heating systems will be installed in same. Bonds amounting to $300,000 were voted upon for the project.

Cal., Los Angeles—The Los Angeles Ry. Co., Pacific Electric Bldg., is having plans prepared for the construction of a 10 story, 65 x 176 ft. office building on 11th St. and B'way. A steam heating system will be installed in same. C. E. Norenberg, Archt.

Cal., Paradise—The Paradise Irrigation Dist., voted $140,000 bonds to replace 13,000 ft. of open canal with 36-in. pipe line, complete auxiliary reservoir system for high lands of district and complete distributing system. L. M. Edwards, Engr.

Cal., San Francisco—The Bd. of Pub. Wks. will soon award the contract for the construction of a 3 story, 82 x 98 ft. school building on Harrison St., between 11th and 12th Sts. An oil burner furnace, low pressure vacuum steam heating system, electric power and a motor driven vacuum pump will be installed in same. Total estimated cost, $108,000. John Reid, Jr., 1st Natl. Bank Bldg., Archt.

Cal., Santa Monica—Columbus Cheney is having plans prepared for the construction of a pumping plant, reservoir and water distributing system, etc., on the 500 acre tract about 8 miles north of here. Total estimated cost, $10,000. C. R. Brawner, 621 North Vernon Ave., Los Angeles, Engr.

Cal., Sierra Madre—The City Trustees voted $60,000 bonds to construct a pumping plant, new mains, etc. E. F. Ballon, City Clk. J. E. Mackerran, Engr.

N. S., Bridgewater—The town plans to improve the present water supply system by installing a new pump and wheel building, etc. Total estimated cost, $50,000. C. H. and P. H. Mitchell, Traders Bank Bldg., Engrs.

Que., Lake Magantre—The municipality will soon receive bids for the construction of a dam on the Chaudieve River capable of furnishing 500 hp. Estimated cost, $225,000. N. A. Girard, Engr.

Ont., London—The Bd. Educ., Dundas St., engaged L. V. Carrothers, Archt., Hydro Bldg., to prepare plans for the construction of two public school buildings and one collegiate institute. A vacuum steam heating and ventilating system will be installed in same. Total estimated cost, $400,000.

Ont., Oshawa—The town engaged R. W. Angus, Engr., University of Toronto, Toronto, to prepare plans for the construction of a waterworks system. An electrically driven, centrifugal pump will be installed in same. Total estimated cost, $80,000.

Ont., Sarnia—Martin & Sperry c/o J. B. Sperry, Huron Ave., Port Huron, have purchased a site on Front St., and plan to build a 4 story mercantile and hotel building on same. A steam heating system will be installed in same. Total estimated cost, $200,000.

CONTRACTS AWARDED

Mass., Greendale—(Worcester P. O.) The Norton Co., Bathers Crossing, has awarded the contract for the construction of a 6 story, 42 x 175 ft. manufacturing plant addition on New Bond St., to E. J. Cross Co., 82 Foster St. A steam heating system will be installed in same. Total estimated cost, $250,000.

Mass., Holyoke—John J. Kirkpatrick of the Municipal Lighting Plant has awarded the contract for the installation of boilers in plant, to the Edgemoor Co., Edgemoor, Del., at $39,972; for stokers, to the Westinghouse Co., Chicopee Falls, at $15,900; for furnishing superheaters, to the Foster Specialty Co., at $7,560.

Mass., West Springfield—(Springfield P. O.) The Gilbert & Barker Mfg. Co., Cold Springs Ave., have awarded the contract for the contruction of 12 buildings, including a 1 story, 50 x 92 ft. power house addition, 1 story, 35 x 50 ft. stone blast building, 1 story, 40 x 72 ft. engine house, etc., to Tucker & Lewis, Inc., 101 Park Ave., New York City. Total estimated cost, $1,000,000. Noted Feb. 2.

N. Y., Brooklyn—S. Wisglass & Co., manufacturers of brass beds, will build a 1 story, 18 x 67 ft. garage, 1 story, 25 x 45 ft. boiler house, 1 story, 25 x 50 ft. power house and a 2 story, 44 x 100 ft. extension to roof of existing factory, on Milford St. and Atlantic Ave. A steam heating system will be installed in same. Work will be done by day labor.

N. Y., New York—The Battle Iron Truck Co., 44 Court St., Brooklyn, has awarded the contract for the construction of a 5 story, 100 x 100 ft. garage on 57th St. and 11th Ave., to Louis Gold, 44 Court St., Brooklyn. A steam heating system will be installed in same. Total estimated cost, $250,000.

N. Y., New York — Farquharson & Wheelock, 724 5th Ave., will build a 12 story office building at 724-726 5th Ave. A steam heating system will be installed in same. Total estimated cost, $500,000. Work will be done by day labor.

N. Y., New York—The Hide & Leather Realty Co. has awarded the contract for the construction of an 18 story, 75 x 80 ft. office building on Gold St., to Thompson & Binger, 280 Madison Ave. A steam heating system will be installed in same. Total estimated cost, $400,000.

N. J., Newark — The Bd. Educ. Essex Bldg., has awarded the contract for the installation of a steam heating system in the proposed 3 story, 70 x 86 ft. addition to the Franklin School, to John H. Cooney, 210 North 4th St. Noted April 6.

N. J., Trenton—The Nearpara Rubber Co., 79 Prince St., has awarded the contract for the construction of a 1 story, 100 x 125 ft. rubber plant, to the Bethlehem Constr. Co., Bethlehem Trust Bldg., Bethlehem, Pa. Plans include a 1 story, 30 x 30 ft. power house. Total estimated cost, $150,000.

Pa., Philadelphia—The Bureau of Water Supply, City Hall, has awarded the contract for the construction of a super-structure pumping station for the Lardners Point Station, to Charles H. Dadney, Bellevue Court Bldg., at $47,000.

Pa., Pittston — St. John's Catholic Association has awarded the contract for the construction of a 3 story, 90 x 180 ft. high school on Dock St., to John Curtis & Co., Hickory St., at $250,000. A steam heating system will be installed in same.

O., Cleveland—The city has awarded the contract for the installation of a heating system in a bath house, here, to the Chafer Co., 131 Champlain Ave., at $32,007. Noted [illegible]

O., Cleveland—The Langaneau Mfg. Co., 5403 Franklin Ave., has awarded the contract for the construction of a 2 story, 40 x 50 ft. boiler house, to the H. G. Slatmyer & Son Co., 203 Lakeside Ave. One boiler will be installed in same. Total estimated cost, $50,000.

O., East Cleveland (Cleveland P. O.)—The Natl. Lamp Co. of the General Electric Wks., Nela Park, has awarded the contract for the construction of a 1 story, 100 x 220 ft. laboratory at Nela Park, to the Austin Co., 16112 Euclid Ave., Cleveland. A steam heating system will be installed in same. Total estimated cost, $100,000.

Ind., Indianapolis—The Bd. Educ., Meridian and Ohio Sts., has awarded the contract for the installation of a heating, ventilating and lighting system in the proposed 3 story, 90 x 194 ft. high school on Merrill St., to Freyn Bros., 31 West Michigan St., at $62,571.

Mich., Kalamazoo—The Handling Knight Co., c/o J. I. Handley, has awarded the contract for the construction of a 3 story, 80 x 800 ft. auto factory along the Lake Shore and Grand Trunk Rys., to Henry L. Van der Horst. A steam heating equipment will be installed in same.

Ill., Chicago—The Troco Nut Butter Co., 30 North Michigan Ave., has awarded the contract for the construction of a 4 story, 100 x 112 ft. factory on 37th and Iron Sts., to the E. W. Sproul Co., 2001 West 39th St. A steam heating system will be installed in same. Total estimated cost, $250,000

Wis., Milwaukee—The Federal Cone & Candy Co., 100 George St., has awarded the contract for the construction of 3 story, 50 x 60 ft. candy factory on Holton St., to W. Tuckwell, 86 Michigan St. Motors will be installed in same.

Minn., Virginia — St. Louis Co., Court House, has awarded the contract for the installation of a steam heating system in the proposed 2 story, 75 x 125 ft. court house addition on Central Ave., to S. Farrell Co., West 1st St., Duluth, at $22,222.

Cal., San Diego—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., has awarded the contract for furnishing and installing standard electric distribution systems and power plant equipment, to the Thomas Haverty Co., 801 Maple St., Los Angeles, at $189,650. Noted March 23.

Cal., Long Beach—The Halfhill Tuna Packing Co. has awarded the contract for the construction of a refrigeration plant, etc., at Channel 3, to G. D. Sanford, 415 East 17th St. Estimated cost, $40,000.

Cal., Los Angeles—King W. Vidor has awarded the contract for the construction of seven 1 and 2 story motion picture producing buildings on Santa Monica Blvd., to the Milwaukee Bldg. Co., 316 Wright and Callender Bldg., at $100,000.

Cal., Salinas—The Trustees of the Salinas Union High School Dist. has awarded the contract for the construction of a 2 story high school, to McLeran & Peterson, Hearst Bldg., San Francisco, at $235,400. A steam heating system will be installed in same.

Cal., San Francisco—The Standard Oil Co., 200 Bush St., has awarded the contract for the construction of a 20 story, 137 x 206 ft. office building on Bush and Sansome Sts., to the P. J. Walker Co., Monadnock Bldg. A boiler plant, compressor, motors, etc., will be installed in same. Total estimated cost, $5,000,000.

Equipment Wanted
Equipment For Sale
Positions Vacant
Positions Wanted
Business Opportunities
Plants For Sale
Contracts To Be Let
Patents For Sale
Partners Wanted
Salesmen Wanted

See Pages 87 to 99

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